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PROCEEDINGS OF THE WORLD SCIENTIFIC CONFERENCE ON THE BIOLOGY AND CULTURE OF SHRIMPS AND PRAWNS

ACTES DE LA CONFÉRENCE SCIENTIFIQUE MONDIALE SUR LA BIOLOGIE ET L'ÉLEVAGE DES CREVETTES

ACTAS DE LA CONFERENCIA CIENTIFICA MUNDIAL SOBRE BIOLOGIA Y CULTIVO DE CAMARONES Y GAMBAS

Mexico City, Mexico, 12-21 June 1967
Mexico (Mexique), 12-21 juin 1967
Ciudad de México, México, 12-21 junio 1967

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ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION
ROME, 1968

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VOLUME II - REVIEW, REGIONAL SUMMARY AND EXPERIENCE PAPERS

VOLUME II - EXPOSES GENERAUX, RESUME REGIONAL ET COMPTES RENDUS D'EXPERIENCES

VOLUMEN II - DOCUMENTOS DE RESEÑA, RESUMEN REGIONAL Y DOCUMENTOS DE INVESTIGACION

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Rome, October 1968 Rome, octobre 1968 Roma, octubre 1968

PREPARATION OF THIS VOLUME

This volume contains the corrected review, regional summary and some of the experience papers contributed to the FAO World Scientific Conference on the Biology and Culture of Shrimps and Prawns, in Mexico City, Mexico, 12 to 21 June, 1967, and which were originally distributed to the participants and authors.

The first volume contained the Report of the Conference and the subsequent volumes will contain the remaining experience papers and the species synopses papers.

The views expressed in the contributions are those of the authors and not necessarily of the Food and Agriculture Organization of the United Nations.

Dr. D.I. Williamson and Dr. (Mrs.) S. Pillay assisted in the editing of some of the contributions and Dr. L.B. Holthuis assisted in the nomenclature.

PREPARATION DU PRESENT VOLUME

Le présent volume contient les exposés généraux et le résumé régional ainsi qu'un certain nombre de comptes rendus d'expériences présentés à la Conférence scientifique mondiale sur la biologie et l'élevage des crevettes, tenue à Mexico (Mexique) du 12 au 21 juin 1967, et initialement distribués aux participants et aux auteurs.

Le premier volume contenait le rapport de la Conférence et les volumes suivants contiendront le reste des comptes rendus d'expériences et les synopsis d'espèces.

Les opinions exprimées dans les communications sont celles des auteurs et ne représentent pas nécessairement celles de l'organisation des Nations Unies pour l'alimentation et l'agriculture.

M. D.T. Williamson et Mme. S. Pillay ont collaboré à la mise au point de certaines des communications et M. L.B. Holthuis a collaboré à la nomenclature.

PREPARACION DE ESTE VOLUMEN

Este volumen contiene la revisión corregida de algunos de los documentos de reseña, resúmenes regionales y documentos de investigación presentados a la Conferencia Mundial de la FAO sobre Biología y Cultivo de Camarones y Gambas, celebrada en Ciudad de México, México, del 12 al 21 junio de 1967, los cuales fueron distribuidos entre los participantes y autores.

El primer volumen contiene el Informe de la Conferencia. Los volúmenes siguientes contendrán los documentos de investigación remanentes y las sinopsis de especies.

Las opiniones expresadas en los documentos son las de los autores y no reflejan necesariamente las de la Organización de las Naciones Unidas para la Agricultura y la Alimentación.

La Dra. S. Pillay y el Dr. D.I. Williamson prestaron su colaboración para la redacción de algunos de los documentos y el Dr. L.B. Holthuis colaboró en la nomenclatura.

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THE TYPE OF DEVELOPMENT OF PRAWNS AS A FACTOR DETERMINING SUITABILITY FOR FARMING

by

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Abstract

Larvae of decapod Crustacea usually require different food and environmental conditions from juveniles and adults. It is suggested that in culture the problems of rearing larvae could be eliminated or greatly reduced by selecting species with direct or abbreviated development. Examples of shrimps and prawns with rapid post-embryonic development are given, and studies on their biology in captivity to assess their suitability for culture are proposed.

LE TYPE DE DEVELOPPEMENT DES CREVETTES EN TANT QUE FACTEUR DETERMINANT LEUR APTITUDE A L'ELEVAGE

Résumé

Les larves des crustacés décapodes ont en général besoin de nourriture et de conditions de milieu différentes de celles qui conviennent aux jeunes et aux adultes. On pourrait peut-être éliminer ou réduire considérablement les problèmes que pose l'élevage des larves en choisissant des espèces ayant un développement direct ou abrégé. La communication donne des exemples de crevettes ayant un développement post-embryonnaire rapide et propose des études sur leur biologie en captivité afin de déterminer si elles conviennent à l'élevage.

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EL TIPO DE DESARROLLO DE LOS CAMARONES COMO FACTOR QUE DETERMINA SU ADAPTABILIDAD AL CULTIVO EN ESTANQUES

Extracto

Las larvas de los crustáceos decápodos requieren por lo general alimentos y condiciones ambientales distintas de los indivíduos juveniles y adultos. Se sugiere que en el cultivo se eliminen o reduzcan grandemente los problemas de la cría de las larvas mediante una selección de especies que tengan un desarrollo rápido o abreviado. Se indican ejemplos de camarones y langostinos de rápido crecimiento postembrónico y se proponen estudios sobre su biología en cautividad para determinar la conveniencia de su cultivo.

1 INTRODUCTION

Not all decapod crustaceans are equally suitable for human food, and not all are equally easy to rear in captivity. The range of edible species is, however, very broad, and few species which appear suitable for farming or culture are inedible. The first criterion of suitability for culture must be the ease and cost of rearing on a large scale. Stock selection at sub-specific level, based on such factors as growth rate, flavour and resistance to disease can be envisaged in the future, but the problem at the moment is that of selection at the specific level.

Cultivation by impoundment or any form of culture in which the young of wild stocks are trapped must be dependent on local species. A considerable amount of species selection can, however, be exercised by the method of trapping and its timing. The present paper is chiefly concerned with methods of cultivation in which the young are reared in tanks, and consideration need not be limited to local species.

2 AVOIDANCE OR SIMPLIFICATION OF LARVAL REARING

Most decapods pass through a number of larval stages, and the environmental requirements of larvae are almost invariably different from those of juveniles and adults. The larvae are normally planktonic while the later stages may be either nektonic or benthic. In some cases the larvae have different temperature and salinity requirements from the later stages, and in all cases they have different food requirements. In order to farm a typical prawn it is, therefore, necessary to have two fairly distinct units, one catering for the physical, chemical and food requirements of the larval stages and one supplying the needs of the post-larval stages.

Prawns which are cultivated on a commercial scale are drawn almost entirely from the families Penaeidae and Palaemonidae (species listed by Holthuis and Rosa, 1965) and all are species which pass through five to ten feeding zoeal stages. The Penaeidae also pass through a number of naupliar stages, but these are of brief duration and do not feed (Gurney, 1942). Today, prawn cultivation is mostly by impoundment, and since the larval stages are not reared in captivity their number, duration and feeding habits are of little direct concern to the cultivator. These factors are, however, of very great concern to the farmer who raises all developmental stages of his stock in captivity, and interest in this form of prawn cultivation is now growing rapidly in several countries. The few pre-farming studies conducted have concentrated on determining and supplying the larval requirements of species which are already commercially important in the area, and such investigations have met with considerable success in the case of the penaeid Penaeus japonicus Bate (Hudinaga, 1942) and the palaemonid Macrobrachium rosenbergii (de Man) (Ling, 1962). While these examples show that the problems of large-scale rearing of larvae may in some cases be successfully surmounted, it is the purpose of this paper to point out that, by the selection of suitable species, these may largely be eliminated. A number of Caridea and Stenopodidea hatch in near-adult form and in others the larvae feed only on internal yolk. It is suggested that some of these species may well prove suitable for large-scale farming and that the difficulty and cost of rearing them could be much less than for species with typical larvae. Some suggestions for further investigations of such species are made below.

Among species which feed in the zoeal stages, those which hatch as large larvae and complete their larval development within a few moults seem to be better suited for cultivation in captivity than species which hatch as small larvae and pass through many moults before metamorphosis. Their larval life will be shorter, and they should, in general, accept a greater variety of foods. Suggested foods include adult copepods from natural plankton and young amphipods from either wild or farmed populations. Some large larvae may accept non-living food, whereas all small zoeas seem to feed only on living planktonic species. Large larvae would not be dependent on the newly-hatched nauplii of Artemia, which form the standard laboratory food for most zoeas.

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Artemia nauplii are invaluable for the laboratory rearing of decapod and fish larvae, but the number of large-scale rearing projects relying on this food is steadily increasing, and there is a danger that the supply of Artemia eggs will eventually limit such operations, apart from being a major expense in the budget of any farm dependent on it.

3 SPECIES WITH DIRECT OR RAPID DEVELOPMENT

Decapod Crustacea which undergo direct or rapid development tend to occur more commonly in fresh and brackish waters and in the deeper and colder parts of the marine environment, although other species which pass through a long series of larval stages may also occur in the same environments (Gurney, 1942). Species with abbreviated development almost invariably have fewer and larger eggs than comparable species with a more typical development. An extreme case is provided by Richardina spinicincta A. Milne Edwards (Stenopodidae) in which a female may carry as few as six eggs (Kemp, 1910), although females of most Decapoda with direct or abbreviated development can carry over 50 eggs and many carry several hundreds. The prospect of rearing eggs to juveniles with lower mortality and at lower cost will generally compensate for the smaller number of eggs per female. Hardly any prawn with a suitable type of development seems likely to be rejected as a potential species for farming on the grounds that the female carries too few eggs.

Species from water of reduced salinity are frequently tolerant of a wide range of environmental conditions and can often withstand comparatively rapid changes in these conditions. This hardiness makes many of these species suitable for cultivation by impoundment, and a number of them grown in this way are listed by Holthuis and Rosa (1965). In the case of impoundment the length of larval life is of little importance, but those species which are suitable for this form of cultivation and which also have abbreviated larval development should be particularly suitable for farming.

Few attempts have been made to keep deep-sea prawns alive in captivity and difficulties can be foreseen in many cases. Some species may require very constant conditions, others may need to carry out extensive vertical migrations, and some may require the presence of undefined chemical factors which are not present in coastal waters (Wilson, 1951). Further knowledge of the habits and requirements of deep-sea species is, therefore, very desirable, and a number of species may eventually be found which are suitable for farming.

Arctic and antarctic seas and sub-polar waters offer what appears to be the most promising source of shrimps and prawns for farming. Many of the species from these areas are quite large and a high proportion have abbreviated larval development. It seems likely that some will breed only in relatively cold water, and a prawn farm in temperate or tropical regions might have to supply cooled water for the breeding stock. There is, however, the exciting possibility that juvenile prawns may be acclimatised to the local sea temperature, where they might be expected to show an increased growth rate. Such a system, involving the cooling of relatively small volumes of water, seems preferable to systems which have been suggested for temperate regions which involve the heating of considerable volumes of water for the growing stock. Species which occur in cold coastal waters may well prove the most suitable for farming in warmer coastal waters.

Examples of shrimps and prawns showing different types of rapid post-embryonic development are given below, and remarks are made on some aspects which are likely to affect their suitability for farming. In addition to the species mentioned here, many more are known to have large eggs and it is probable that their larval development is abbreviated, but there is no published indication as to whether or not the larvae feed or in what form the animal hatches (Gurney, 1939). It should be noted that different species of the same genus may show considerable variation in the state of development at hatching. The wide variation within the genus Pandalus Leach is discussed by Pike and Williamson (1964).

3.1 Species with no free larval stages

The most satisfactory zoological definition of "shrimps and prawns" is to equate them with the Macrura Natantia, and the only practicable distinction between shrimps and prawns is one of size. The fresh-water crayfishes (Astacidae and Parastacidae) cannot be included as prawns in the zoological sense, but they lend themselves to similar culinary treatment and to similar farming methods. Development is direct in all known members of both families; the only larval characters of the newly-hatched young are the absence of first pleopods and uropods and the virtual absence of setae on any of the appendages. The young are never pelagic and they remain attached to the pleopods of the parent for at least one instar. They hatch with considerable supplies of yolk and probably take no other food until after one or two moults. The culture of fresh-water crayfishes is discussed by Smolian (1925).

Several Macrura Natantia have no pelagic larval phase in their development. In Sclerocrangon boreas (Phipps) and S. ferox (G.O. Sars) the newly-hatched young show rather similar development to those of the Astacidae and Parastacidae, and they apparently remain attached to the pleopods of the female, without feeding, until they reach Stage III (Wollebaek, 1906, 1908, and personal observations). On the other hand, S. intermedia (Stimpson) and S. salebrosa (Owen) have recently been shown by Makarov (1966) to pass through several pelagic zoeal stages. The genus contains at least eight other species whose development is not described. All species are bottom-living as adults.

S. boreas appears to have considerable potential as a species for farming. It is a large prawn, reaching a length of over 12 cm, and is widely distributed in the colder waters of both North Atlantic and North Pacific Oceans. It is most common in waters of less than 100 m and occasionally occurs intertidally (Wollebaek, 1908; Heegaard, 1941). S. ferox occurs in the arctic Atlantic at greater depths than S. boreas and usually in colder water. Its suitability for rearing in captivity also merits investigation, and the type of development of other species of Sclerocrangon G.O. Sars should be studied.

There is also no pelagic zoeal stage in the development of some species of Synalpheus Bate (Alpheidae) and in all known species of Cryptocheles G.O. Sars and Bythocaris G.O. Sars (Hippolytidae) (Dobkin, 1965a; Sars, 1912). The young of these forms do not attach to the pleopods of the parent; they may emerge either as juvenile shrimps, with no larval characters, or as 'pseudo-larvae', with vestigial exopods on some of the legs. The 'pseudo-larva' is incapable of locomotion and quickly moults to the juvenile form. Although there is a tendency towards abbreviated development throughout the genus Synalpheus, the pelagic larval phase is completely suppressed in only a minority of species. The small size of adults of Synalpheus and the fact that they normally live inside sponges and other animals probably makes them unsuitable for farming. Most of the known species of Cryptocheles and Bythocaris are also rather small, but B. leucopis G.O. Sars can exceed 9 cm in length. Records of this species are from 320 m to over 2000 m depth, chiefly from the Norwegian Sea (Heegaard, 1941).

3.2 Species in which the larvae do not feed

A number of Decapoda are known to pass through one or two zoeal stages which are nourished entirely on internal yolk and which have no functional mouth parts. Most of the known prawns in this category occur in the families Oplophoridae and Pasiphaeidae; they are pelagic species often inhabiting deep water and they may be difficult to keep in captivity. A benthic prawn in the same category is Glyphocrangon spinicauda A. Milne Edwards (Glyphocrangonidae), whose development is described by Dobkin (1965 b). Other members of the Glyphocrangonidae probably develop in the same way; all appear to be restricted to deep water.

3.3 Species with few larval stages

Prawns which hatch as large larvae and pass through only one or two zoeal stages are known from the families Pandalidae, Hippolytidae and Crangonidae. The following examples are all coastal species:

Pandalus kessleri Czerniavski is fished in parts of northern Japan but is apparently not farmed. It hatches as a very advanced zoea, about 8 mm long, which moults within a few days to give a megalopa (postlarva) with functional pleopods (Kurata, 1955). Pandalopsis coccinata Urita, also from Japanese waters, is about 15 mm long on·hatching. The stage which emerges from the egg is probably bottom-living, its only truly zoeal characters being the form of the telson and the antennules (Kurata, 1964). This species might equally well be included in section 3.1 ("Species with no free larval stages").

There is no complete description of post-embryonic development in the hippolytid genus Lebbeus White, but L. polaris (Sabine) and L. groenlandicus (Fabricius) probably hatch as very advanced zoeas, measuring about 8 mm, and pass through not more than two zoeal stages (Pike and Williamson, 1961). L. polaris has a pan-arctic distribution, and L. groenlandicus extends from north-eastern Asia through North American waters to Greenland (Heegaard, 1941, both as Spirontocaris).

Argis lar (Owen) (Crangonidae) measures 8 - 10 mm in stage I and probably passes through only two zoeal stages, although Squires (1965) thought that there may be other zoeal stages which have not been observed. The distribution of this species (Heegaard, 1941, as Nectocrangon) is very similar to that of L. groenlandicus. Several other species of Argis Krøyer occur in the colder parts of the North Pacific Ocean but their development has not been described.

4 RECOMMENDATIONS

There is an obvious need for extensive studies on the biology of prawns in captivity to determine their suitability for farming, and it is urged that cold water species with abbreviated development should receive particular attention. The species which have been suggested in this connection in this paper are mostly from boreal and arctic seas, but it is likely that equally suitable species are to be found in the colder waters of the southern hemisphere. There are also a great many northern prawns whose development has not been studied, and it is probable that a number of these have types of development similar to those which have been mentioned.

The chief object in choosing prawns with abbreviated larval development for farming is to reduce or eliminate the problem of feeding the larvae. It does not, of course, reduce the problem of feeding the juveniles and adults, but this should be no more of a problem than for prawns with typical larval development. Suitable food for the juveniles and adults will in most cases have to be determined by trial, although knowledge of natural foods may be very helpful. It is suggested that gammarid amphipods, which often thrive on a diet of partly decayed vegetable matter, may prove a relatively economical food for some prawns. It is also suggested that, provided recently hatched nauplii of Artemia salina are not required, parthenogenetically reproducing cultures of this species are likely to provide a cheaper source of live prawn food than populations raised directly from resting eggs. It is probable that many prawns will take a variety of non-living foods, including 'prepared' foods based on fishmeal and other inexpensive sources of protein.

One of the most difficult factors to control is the chemical composition of the water in which prawns are to live, and in many cases it is not known which chemical factors are important for the growth and reproduction of the species (Wilson, 1951). In most cases, therefore, selection of species which will thrive in the local water is another matter which will have to be determined by trial, although, in general, shallow water species are likely to be tolerant of a wider range of both chemical conditions and temperature than are deep water and oceanic species.

Pre-farming studies on prawns should include observations on the effects of temperature, salinity, food and crowding on growth-rate and survival at different stages in the life history and the effects of these conditions on breeding. If the breeding stock is kept under different conditions from the growing stock, then the time of transfer of the young prawns and the method of acclimatisation must be matters for further experiment. It is to be hoped that many different techniques will be tried in many different regions with a view to finding a range of species suitable for farming under a range of conditions. Not only will these conditions vary geographically but within any region the potential growing habitats will include man-made tanks and ponds and natural bodies of water of a great variety of shapes and sizes.

Finally, it is recommended that consideration of species for farming should not be limited to those which are abundant in nature. The experience of many biologists seems to show a complete absence of correlation between the commonness of plants and animals in natural aquatic environments and the ease with which they may be reared in captivity.

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PRAWN CULTURE IN SINGAPORE

by

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Abstract

The method of prawn culture in Singapore differs from the one used in the Philippines mainly in that young prawns are not stocked in the pond by operators but are brought in by tidal flow. The method appears simple, yet many operators have failed to achieve success because they are not sufficiently experienced in the selection of the site, and in the construction, operation and maintenance of the pond. In this paper these methods, which are largely empirical, are described and an attempt made to explain the basic principles involved.

L'ELEVAGE DES CREVETTES A SINGAPOUR

Résumé

La méthode d'élevage des crevettes à Singapour se distingue de celle utilisée aux Philippines surtout par le fait que les jeunes crevettes ne sont pas introduites dans l'étang par les exploitants mais sont apportées par le flux de la marée. Cette méthode paraît simple, et pourtant de nombreux exploitants ont échoué faute d'une expérience suffisante dans le choix de l'emplacement ainsi que dans la construction, l'exploitation et l'entretien de l'étang. On s'attache ici à décrire les méthodes utilisées, qui sont en grande partie empiriques, et on s'efforce d'expliquer les principes fondamentaux à respecter.

EL CULTIVO DE LOS CAMARONES EN SINGAPUR

Extracto

El método del cultivo de camarones en Singapur se diferencia principalmente del empleado en Filipinas en que los cultivadores no sueltan los camarones jóvenes en el estanque sino que éstos llegan a él con la marea. Aunque el procedimiento parece sencillo, sin embargo muchos productores no han podido aplicarlo por carecer de suficiente experiencia en la elección del lugar y en la construcción, funcionamiento y conservación del estanque. En este estudio se describen tales métodos, que en gran parte son empíricos, tratando de explicar los principios básicos pertinentes.

1 INTRODUCTION

The method of prawn culture in Singapore originated more than 30 years ago and has been improved over the years as a result of experience. It differs from the method used in the Philippines, as described by Villadolid and Villaluz (1951), mainly in that the prawn ponds in Singapore are not stocked with young prawns by the operators. It is believed that young prawns enter the ponds with the tides. This method is extremely simple and appears to take advantage of the peculiar aspects of the biology of prawns belonging to the family Penaeidae. The local fishermen construct earth bunds to form ponds which receive the incoming tidal currents through sluice gates twice a day and let off the excess water with the receding tide, keeping the water level at about 2 ft (61 cm).

This method of prawn culture has been described by Burdon (1950), Tham (1955) and Hall (1962). The first two of these reports are rather general and many details in respect of site selection, construction, operation and maintenance have not been mentioned. During the last 30 years the author had the opportunity of discussing this method of prawn culture with many operators with extensive experience. These operators are normally rather uncommunicative regarding the details of their operations which are considered occupational secrets. Some of the practices detailed in this paper are used by all the local operators while a few others are used only by some and no single operator employs all of them. These details are, however, vitally important to the success of the project. The purpose of this paper is to draw attention to the details of the method used and to review the probable basis for such practices.

2 SELECTION OF SITE

Although, generally speaking, all the brackish-water swamps along the coast of Singapore and the southern coast of Johore (the southernmost state in West Malaysia) are suitable for the cultivation of penaeid prawns, the cultivator normally chooses the site with care, as the production of the pond as well as the cost of construction and maintenance depend on the following factors:

(i) The presence of the commercially important species of prawns in the area

(ii) The tidal range at the site

(iii) The location of the site in relation to the coast

(iv) The depth of the swamp

(v) The suitability of the bottom soil

(vi) The size of the swamp

(vii) The presence of large fresh-water streams draining into the swamp

(viii) The salinity of the sea water draining into the swamp

The penaeid prawns which may be caught locally in quantity and which have a high market value are the following:

(i) *Penaeus indicus* H. Milne Edwards, 1837

(ii) *Penaeus merguiensis* de Man, 1888

(iii) *Metapenaeus ensis* (de Haan, 1844) = *M. mastersii* (Haswell, 1879)

R/2

(iv) Metapenaeus burkenroadi Kubo, 1954

(v) Metapenaeus brevicornis (H. Milne Edwards, 1837)

The larger prawns have a higher market value, those of about 4 cm carapace length (measured from the inside of eye socket to the posterior end of carapace) fetching the maximum. Where the sizes are equal the members of the genus Penaeus have a higher value. Among these the banana prawn P. merguiensis has the highest market value, followed by the Indian prawn P. indicus, the giant tiger prawn P. monodon and and the green tiger prawn P. semisulcatus. Among the members of the genus Metapenaeus, the yellow prawn M. brevicornis commands the highest price in the local markets. In the selection of a site, the prawn pond operators attempt to assess if the most valued species are present in sufficiently large numbers to make the project economically viable. Cast nets and filter nets are operated in the proposed swamp site and if the catches yield a high percentage of carideans as compared to penaeids the site is not considered a good one for prawn culture.

The tidal range at the site is considered important by the pond operators because they prefer to harvest their ponds daily if possible in order to have fresh prawns for sale every day. The local consumers pay a higher price for freshly caught prawns. They do not realise, however, that the productivity of the pond depends on the volume of tidal flow since in this method of prawn culture the young prawns as well as their food are brought into the pond by the daily tidal flow. But even in Singapore, where there are two high waters every day and the height of high water at spring tide is 11 ft (3.35 m) or a little more, they can only harvest on about 22 days in a month. During the height of the neap tides there is no harvesting. Generally, the tidal range is always considered together with the height of the swamp site. The two should be such that harvesting could be carried out on about 20 to 22 days in a month. If the level of the swamp is too high, no water will enter the pond even during high water at neap tide. This results in a lower number of operational days in the month. For example, if the swamp is 4 ft (1.2 m) above the level of lowest low water at spring tide, there is at least a difference of 2 to 3 ft (0.6 to 0.9 m) between the level of the swamp and the lowest high water at neap tide, in Singapore. This range is considered suitable. If the height of the swamp is much more than 4 ft (1.2 m) there will be too many days in the month when the pond remains without sea water and this is considered undesirable. Where the high water level at spring tide is unduly high, e.g. more than 14 ft (4.3 m), this is also considered unsuitable because it would involve building higher and stronger bunds, resulting in high cost of construction and maintenance.

Another important consideration is the location of the site in relation to the coast. The site should be near the coast but not so near as to cause the damage to bunds by continuous wave action. It should not be too far inland since there is then a danger of flooding with rain water during the monsoon season. Usually a site along the coast is chosen with a fringe of at least 50 ft (15.2 m) between the beach and the prawn pond, where the mangrove trees serve as protection against wave action.

The next point to be taken into account is the texture of the bottom soil at the site. It should be hard clay and there should be not more than 2 in (5.1 cm) of silt above the clay. It has been found that when the pond bottom is heavily silted the prawn catch declines, as the author observed in the prawn pond owned and operated by the Singapore Fisheries Department from 1954 to 1958. The silt on the bottom of this pond in 1955 was 2 in (5.1 cm), but by 1958 it was nearly 10 in (25.4 cm). The catch dropped from 12,800 lb (5810 kg) in 1955 to 6,000 lb (2720 kg) in 1958. It is still not clear why the catch should drop with the increase in silt level. It has been shown by Dall (1958) that M. bennettae buries itself in mud during the daylight hours; so any increase in silt level should not drive it away. It may, however, be that when the mud is more than 2 in (5.1 cm) deep anaerobic conditions are set up in the mud layer, leading to the production of poisonous gases (such as hydrogen sulphide) which then slowly diffuse through the mud thus deteriorating the habitat of the prawn. Hard clay is preferred also for the construction of the earth bunds that enclose the prawn pond. Bunds built from soft silty material will not last and sink so fast that they cannot be consolidated.

The size of the swamp is also an important consideration, because ponds of less than 20 acres (8.1 ha) are not considered economical to maintain. At least two workers are required even for a pond of 10 acres (4 ha), to open and close the sluice gates four times a day. For large ponds of more than 40 acres (16.2 ha) three or four workers may be required. The smallest size of pond which is economical to maintain under local conditions is 30 acres (12.1 ha) because the income derived from it is sufficient to pay two workers and other operational expenditure and still leave a sizeable profit for the owner of the pond.

Large fresh-water streams draining into the swamp site are not favoured but where other conditions are favourable, steps might be taken to divert the stream if it is not too costly an operation. The salinity of a prawn pond can be lowered considerably by monsoon rainfall if the precipitation on the catchment is drained into it. It is believed that this lowering of salinity will drive out the penaeid prawns. There is also the danger of flooding of the pond during heavy rainfall causing breaches in the bunds.

The salinity of the sea water draining into the swamp is also important. Generally it should not be lower than 18 ‰ at any time during the year. A salinity range of between 24 and 30 ‰ is considered most suitable. The lower limit should never be below 15 ‰.

3 CONSTRUCTION OF POND

For the project to be successful the construction of the pond has to be carefully planned with the following points in mind:

(i) The bunds must be strong enough to withstand the difference in pressure between the water levels inside and outside the pond at any state of the tide.

(ii) They must be high enough to ensure that water will not flow over the top and should be wide enough for operators to walk on the bund itself.

(iii) There must be sufficient number of sluice gates to allow the inflowing tidal current to get into the pond quickly, so that unduly high pressure will not be built up on the outside of the bunds, and also to allow the outflowing water to leave the pond fast enough to obviate any unduly high pressure being built up against the bunds on the inside of the pond.

(iv) The sluice gates must be sited in such a way that the inflowing tide will flow directly through them without generating eddies and whirlpools outside the gates. It is believed that this may scare the young prawns from entering the pond.

(v) The channels bringing the sea water into the pond must be straight or only gently curved and they must be kept clear, as plants growing in the channels will vibrate with the fast flowing current and it is believed that they will deter the young prawns from entering the pond.

(vi) The bottom of the pond must be cleared of mangrove stumps and levelled, as it has been found that removal of the stumps and levelling invariably increased the yield. It may be that retention of these stumps provides a suitable habitat for crabs and other animals which are predatory.

(vii) Channels must be provided on the bottom of the pond to disperse the inflowing water to every part of the pond. These channels should radiate from the sluice gates to the farthest corners of the pond. This arrangement seems to improve the yield, and it is possible that it helps to disperse the young prawns evenly so that they are less vulnerable to predation and enjoy a higher level of food availability. These channels are planned before the construction of the pond, and the clay for the building of the bunds is taken from them, thus fulfulling two objectives.

(viii) The bottom of the pond is graded in such a way that the part nearer to the sluice gates is deeper. This will enable the operators to concentrate the prawns prior to catching.

(ix) To facilitate operation, the sluice gates are built in batteries wherever possible with concrete foundation and sides, and wooden shutters.

(x) The bunds adjacent to the sluice gates are reinforced by wooden piles as otherwise the daily flow of water past the gates will weaken them.

(xi) In the construction of the bunds the clay is removed from the pond bottom in slabs of about 1 ft (30 cm) in length, 6 in (15.2 cm) wide and 4 in (10.2 cm) thick. These slabs are laid side by side to form the bund and each layer is baked in the sun before the next layer is put on. This reduces the sinking rate of the bunds. Even a well-baked and well-built bund has a sinking rate of 1 ft (30 cm) per year. Badly constructed bunds may sink as much as 2 to 3 ft (61 to 91.4 cm) per year. The bunds are built with hand labour which is costly. The author has tried using dredges and earth-movers to build these bunds. Contrary to expectation it is neither cheaper, nor faster, because the bunds have to be built much wider both at the top and bottom and also higher to allow for a greater sinking rate. On account of the soft nature of the terrain and the weight of the machinery, the shifting of the machines consumes a lot of time which adds to the cost of construction.

4 OPERATION AND MAINTENANCE OF POND

The sluice gates are opened when the incoming tide reaches a height of 2 ft (61 cm) above the floor of the sluice gates. This ensures a rush of inflowing water which prevents the prawns swimming out. When the tide has risen to the highest point in the daytime a wire screen of ½ in (1.3 cm) mesh is placed across the gate to prevent escape of any prawn with the receding tide. During the daytime the prawns are 'adsorbed' on the bottom of the pond and the above operation is not to catch prawns but to reduce the water in the pond to such a level that prawn catching can begin at dusk. But if the ebb tide begins at night or at dusk when the prawns will be swimming about, a fishing net of rami netting (usually about 30 ft (9.1 m) long with meshes varying from 5/6 in (2.1 cm) bar at the mouth to 3/8 in (0.95 cm) bar at the cod-end) - with mouth large enough to be fitted to a wooden frame of the same size as the cross section of the gate - has to be fixed in place in the slots on the sides of the gate, just before the tide ebbs. The receding tide then flows through the filter net so that all prawns and fish going through the sluice gate are caught. This procedure serves not only to catch the prawns but also to reduce the level of water in the pond thus equalising the pressure on the bunds both inside and outside. Before the net is hauled up, the water flow through the gate is stopped by operating a wooden windlass which lowers the sluice gate. A wooden trough-like raceway is also provided on the outer side of the sluice so that the net will not be torn when the current rushes through it. The net frame is then lifted and the catch released on the sorting floor by pulling on the rope securing the cod-end of the net.

Damage to nets have to be repaired every day after washing in fresh water and drying in the sun. Once a fortnight they are treated with mangrove bark extract and dried in the sun, after which they are steamed and dried again. The bunds have to be maintained, i.e. breaches and leaks are repaired and they are topped up at regular intervals to make up for the sinking rate. The crustacean known locally as the mud lobster, *Thalassina anomala* (Herbst), builds burrows in the bunds, weakening them and causing leaks. They can be spotted by the funnel-shaped external opening of their burrows and destroyed in any of the following ways:

(i) By placing a piece of calcium carbide, about 1 in (2.5 cm) in diameter in the funnel of the burrow. The acetylene gas given off on contact with water kills the mud lobster.

(ii) By pouring quicklime (calcium oxide) into the funnel. The heat generated on contact with the moist animal will kill it, or

(iii) By pouring a solution of DDT in kerosene into the funnel. This will also kill the mud lobster.

Since the pond is filled twice a day with sea water by the tides, it is obvious that a large number of fish species will get into the pond. Many of these species are predatory to all stages of the penaeid prawns and so production will gradually drop if they are not killed. A list of these species is given by Hall (1962). It has been found by experimentation that 'teaseed cake' is a very efficacious poison as it kills the fish quickly but does not appear to harm the prawns. The active principle in 'teaseed cake' appears to be saponin. In the prawn pond owned and operated by the Singapore Fisheries Department from 1954 to 1958, it was found by a series of experiments that the use of this fish poison once every four months will raise the yield of prawns to at least 1/3 ton per acre (837 kg/ha) per annum. This has now become standard practice in Singapore.

It is also customary to dry the pond bottom in the sun for three or four days before refilling with water. This has the effect of hardening the pond bottom and perhaps also hastening the mineralisation of the organic debris in the soil. It may also help to fertilize the pond by breaking down the hard frustules of the diatoms on the pond bottom enabling the cell contents to run out.

5 DISCUSSION

The method of prawn culture as practised in Singapore consists of provision of rearing ponds for young penaeid prawns which are brought in with every incoming tide. It is certain that very few of the penaeid prawns caught in the pond, entered the pond as large individuals, i.e., of total length greater than 3 cm, because repeated filtration of the inflowing tide with fine nets never produced more than 20 individuals. But filtration of the subsequent outflowing tide always produced more than a hundred individuals, sometimes over a thousand. Hall (1962) working on the plankton catches of a prawn pond in Singapore produced evidence to support the hypothesis that the penaeid prawns entered the pond as larvae or post-larvae and grew in the ponds until they were harvested. This is supported by the work of Dakin (1938), Anderson, Lindner and King (1949), Morris and Bennett (1951) and Racek (1959) which indicate that, apart from one or two species of the genus *Metapenaeus*, the penaeid prawns breed fairly far out at sea. The larval stages are then brought into the littoral and estuarine areas by the tides. There is thus ample evidence to support the view that the penaeid prawns cultivated in the Singapore prawn ponds were hatched at sea, were brought into the prawn ponds by the tides and grew up in the ponds until harvested. Whether these larval stages are carried towards the shore by tidal currents or whether there is also a directed movement resulting from an urge of the larvae to seek an environment of lower salinity is, however, not clear.

From the study of catches of the Sondong push nets operated off the south coast of Singapore by Tham (1955), it appears that many larval stages grow up in the littoral areas without entering the estuarine mangrove areas. It is thus highly probable that the larval stages are just carried into the estuarine areas by tides and are indifferent to the slightly lower salinity. Racek (1957) came to a somewhat similar conclusion when he stated that probably only a small portion of the penaeid larvae and post-larvae would ever reach the estuaries whereas the rest might spend their whole life cycle at sea. On the other hand, the predominance of certain species, e.g. Penaeus indicus, Metapenaeus ensis, M. brevicornis and M. burkenroadi, in the prawn pond catches in Singapore does not rule out the possibility that these species have a preference, during their juvenile stages, for slightly lower salinity. Other species, such as Parapenaeopsis tenella, species of Trachypenaeus Alcock and Metapenaeopsis barbata which are rather common in Singapore Straits, are rare in the prawn pond catches.

The question of salinity tolerance, or preference, of penaeid prawns, however, deserves further consideration. The prawn pond operators in Singapore have experienced that with heavy drainage of rain water into their ponds, the prawn catches are significantly lowered. According to Hall (1962) the salinity in the pond he studied dropped from a normal range of 24 to 31 $^{o}/oo$ to as low as 4.11 $^{o}/oo$ during periods of heavy rainfall. Certain prawn ponds along the north coast of Singapore have much wider variations in salinity, as the prawn pond studied by Cho (1965) which showed a range of 15 to 27 $^{o}/oo$. With heavy rainfall the drop in salinity in such a pond might be even more marked. Racek (1957) states that the mass migration of prawns of all age groups, from the estuaries to the ocean during extensive river floods is a result of a rapid fall in salinity. This supports the observation of the local prawn pond operators.

One point in the construction of the pond which merits discussion is the belief that the young prawns may be frightened by noise due to eddies or vibrations of weeds and plants in the intake channels. This belief is based on the common knowledge among local fishermen that, when agitated by sounds such as those caused by rowing with oars, penaeid prawns will jump out of the water into their boats. The practice of keeping the channels leading from the sea to the sluice gates, free of weeds and obstruction is known to improve prawn pond catches. The other point relates to the construction of channels radiating from the sluice gates to the farthest corners of the pond. This may be expected to have two effects, viz: (i) the even distribution of the young penaeids as well as food and (ii) the avoidance of turbulence in the pond. Turbulence in a heavily silted pond may be expected to stir up undesirable gases such as hydrogen sulphide which have been formed under anaerobic conditions. This would creat an environment unconducive to the young penaeids, thus driving them out of the pond and lowering the production.

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THE BIOLOGY OF MASS OCCURRENCES OF GALATHEID CRUSTACEANS AND THEIR UTILIZATION AS A FISHERIES RESOURCE

by

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Abstract

Five known species of Galatheidae exhibit the phenomenon of mass occurrences, mostly in highly eutrophic regions of the ocean. Two of the species (Munida gregaria and Pleuroncodes planipes) occur in vast pelagic swarms as juveniles or young adults, and both species have the capacity to graze on diatom blooms. These two species and M. subrugosa, Cervimunida johni and P. monodon occur in benthic concentrations on some parts of the continental shelf, often in water of very low oxygen tension. A fishery off Chile for the last two of these species lands 10 x 10^3 metric tons yearly, and it is postulated that the unexploited populations of Pleuroncodes planipes could produce similar or greater yields. It is probable that a demersal fishery for this species will shortly be developed, and it is possible that the fishery may include exploitation of the pelagic phase, though this seems less practicable. It is tentatively postulated that the five species of galatheids reviewed may have a total annual potential of between 30 x 10^3 and 300 x 10^3 tons, under the same type of exploitation as has developed in the Chilean fishery.

LES APPARITIONS MASSIVES DE GALATHEES : BIOLOGIE ET UTILISATION COMME RESSOURCE HALIEUTIQUE

Résumé

Cinq espèces connues de Galatheidae se concentrent en essaims massifs, principalement dans les régions fortement eutrophiques de l'océan. Deux d'entre elles Munida gregaria et Pleuroncodes planipes, forment de grands rassemblements pélagiques aux stades juvénile ou jeune adulte, et toutes deux peuvent brouter les bancs de Diatomées. Ces deux espèces, ainsi que M. subrugosa, Cervimunida johni et P. monodon, se trouvent en concentrations benthiques en certains points du plateau continental, souvent dans les eaux à très faible tension d'oxygène. Au large du Chili, la pêche des deux dernières espèces mentionnées produit annuellement 10 x 10^3 tonnes, et l'on suppose que les populations inexploitées de Pleuroncodes planipes pourraient fournir un rendement analogue ou supérieur. Il est probable que l'on entreprendra sous peu la pêche démersale de cette espèce, et il se peut que l'on s'efforce d'exploiter aussi la phase pélagique, bien que ceci paraisse moins faisable. On attribue provisoirement aux cinq espèces de Galathées examinées un potentiel annuel global situé entre 30 x 10^3 et 300 x 10^3 tonnes, pour un type d'exploitation analogue à celui de la pêcherie chilienne mentionnée plus haut.

LA BIOLOGIA DE LA PRESENCIA EN GRANDES CANTIDADES DE CRUSTACEOS GALATEIDOS Y SU APROVECHAMIENTO COMO RECURSO PESQUERO

Extracto

Existen grandes masas de cinco especies conocidas de Galatheidae sobre todo en las regiones altamente eutróficas del océano. Dos de ellas (Munida gregaria y Pleuroncodes planipes) aparecen en vastos enjambres pelágicos de individuos juveniles o adultos jóvenes, y ambas especies se alimentan en las floraciones de diatomas. Estas dos especies y M. subrugosa, Cervimunida johni y P. monodon aparecen en concentraciones bénticas en algunas partes de la plataforma continental, frecuentemente en aguas de muy baja tensión de oxígeno. Una pesquería frente a las costas chilenas desembarca de estas dos últimas especies 10 x 10^3 toneladas métricas anuales, y se supone que las poblaciones sin explotar de Pleuroncodes planipes podrían producir un rendimiento parecido o mayor. Es probable que pueda crearse en breve una pesquería demersal de esta especie, aunque esto parece menos practicable. En principio se supone que las cinco especies de galateidos examinadas pueden tener un potencial total al año entre 30 x 10^3 y 300 x 10^3 toneladas, con arreglo al mismo tipo de explotación que se ha establecido en la pesquería chilena.

1 INTRODUCTION

The Galatheidae are a family of generalized Crustacea Anomura which occur widely, from tropical seas to high latitudes and from the littoral zone down to abyssal depths, generally as members of benthic species assemblages. It appears that at least five of the species which live on the continental shelf can occur in great concentrations at certain times and places within their geographical ranges, and it is these mass occurrences which appear to have fishery potential and which are the subject of this review. Other species in other parts of the oceans may also exhibit the same phenomenon, but have escaped the notice of the reviewer.

In talking of these crustaceans to the fishing industry, one is faced with the problem of their nomenclature in the vernacular; they are neither shrimps nor prawns in the English sense, though they may be utilized by the shrimp industry, nor are they crabs, though the name is often applied to them by fishermen. Having no true vernacular name in any language, fishermen and biologists have applied to them epithets derived from other crustacea, unrelated but of approximately similar appearance: thus the 'red crabs' of the American tuna fishermen, the 'langostino' of the Chilean shrimp fishermen. There is no simple solution to such a problem, except that of being aware of its existence and of taking care to check independently what species or genera are involved.

The five species which are known to show mass occurrences are tabulated below and grouped geographically. It will be noted that all these species have ranges within relatively eutrophic areas of the ocean, in which strong phytoplankton blooms are a seasonal occurrence.

(i) Munida subrugosa (White), Munida gregaria (Fabricius): 'whale-feed', 'lobster-krill'; New Zealand, Tasmania, Sub-Antarctic islands, Patagonia.

(ii) Cervimunida johni Porter: 'langostino azul', 'langostino amarillo'; Pleuroncodes monodon (H. Milne Edwards): 'langostino colorado', 'zanahoria'; Humboldt Current.

(iii) Pleuroncodes planipes Stimpson: 'red crab', 'pelagic crab'; California Current, Gulf of California.

These species appear to share some biological characteristics which may have some significance in the mass occurrences: (i) Each species shows a wide range of feeding mechanisms, often including the capability of grazing, by filtration, upon blooms of the larger phytoplankton organisms. (ii) The life-history includes a postlarval pelagic phase, which may be rather ephemeral, may be repeated later in the life of an individual, or may extend at least until first maturity. (iii) The mass occurrences of adults in the benthic phase tend to occur both in locations below mass diatom blooms and at depths corresponding to those at which oxygen deficient water meets the continental slope.

The paper examines these factors in relation to the distribution and present and future exploitation of the species.

2 SUB-ANTARCTIC RESOURCES

2.1 Biology

The most complete account of the biology of M. subrugosa and M. gregaria is that of Matthews (1932), who shows clearly that these two similar species are in fact distinct, though their geographical ranges very largely coincide. The most important difference between the two species is that M. gregaria is very commonly found in the pelagic as well as the benthic phase, while M. subrugosa has no prolonged pelagic phase after larval development is completed. The following account of these two species is drawn very largely from that of Matthews, based on material from the South Atlantic. Pelagic M. gregaria from off New Zealand have been examined and found to conform exactly to his descriptions of morphology and stomach contents.

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The pelagic phase of M. gregaria is morphologically distinct from the benthic phase, and was described as a separate genus (Grimothea Leach). The principal distinction, apart from a usually lighter and less spinous exoskeleton, is the great development of the third maxillipeds as flattened, foliaceous, filtering appendages in the pelagic phase. In the benthic phase, these limbs remain foliaceous but are relatively much reduced. The young M. subrugosa, on the other hand, closely resemble the adult in all but size from the time of completion of larval development.

The place occupied in the life history of M. gregaria by the pelagic phase (or grimothea stage) has not directly been investigated, but it appears to be of variable duration. Chilton (1909), working on records of the New Zealand population, and Matthews (1932), considering the Patagonian records, were of the opinion that the point in the life history at which settlement occurred was labile and depended upon the circumstances facing the stock of young pelagic individuals. If conditions for settlement into the benthic phase were not suitable (because they found themselves over oceanic depths, for example), they could prolong the pelagic phase, while other stocks would settle early in their lives. It appears possible for the pelagic phase to be extended at least until the time of first maturity, and ovigerous grimothea stages have been recorded for this species. Thus, while the normal pelagic individuals have carapace lengths within the range 7 to 12 mm, and benthic adults 20 to 38 mm, individuals in the grimothea stage may be larger than the smaller benthic adults.

Evidence is given later that an alternation between the pelagic and benthic phases can occur during the life of an individual, but this is apparently not a regular occurrence.

It has been shown that the stomach contents of the pelagic phase frequently comprise masses of partially digested diatoms (Kemp, in Matthews, 1932), and this was confirmed by examination of specimens in the plankton collections of the Scripps Institution of Oceanography. As shown below for Pleuroncodes planipes, it is the function of the third maxillipeds to act as a filtering mechanism when grazing on phytoplankton blooms. On the whole the species is a very catholic feeder, and in the benthic phase it eats small organisms captured by the chelipeds and organic detritus from the upper deposit levels.

2.2 Range of pelagic phase

Matthews (1932) documents many accounts from early voyagers of the mass occurrences of the pelagic phase of Munida gregaria, beginning with that of Sir Richard Hawkins in 1594 who named 'Crabby Cove' in the Straits of Magellan after the fact that the water was 'full of a small kind of red crabbes'. It is evident from these accounts by Dampier, Banks and other early voyagers, together with the modern accounts from, for example, the METEOR and DISCOVERY expeditions, that mass surface occurrences of the grimothea stage are commonplace, especially in the early summer. They are reported from both coasts of Patagonia, to 41°S on the west, and to 51°S on the east, around the Falkland Islands, the coasts of New Zealand and its sub-Antarctic islands, and the coast of Tasmania. Although it is not possible to quantify these accounts, the repetition within them of statements as to the occurrence of 'clouds' of little red lobsters at the surface, of the sea being coloured red with small galatheids, and so on, leaves little doubt as to the magnitude and concentration of the populations.

It is also evident from the published records that these mass occurrences may occur either close to land, over the continental shelf, or over oceanic depths at some hundreds of miles from land. The factors inducing settlement are obscure, but probably are connected with the nutrient cycle of the sea area concerned and the chance of pelagic stocks being carried by horizontal advection off the continental shelf.

There are a few records of adult M. gregaria being taken at the surface, especially along the western coast of Patagonia. These individuals in the DISCOVERY collections do not have grimotheal characters, yet were dip-netted at the surface from enormous concentrations extending from 45°S to 50°S. At the same latitude there are records of windrows of these galatheids being drifted ashore in very great numbers.

2.3 Range of benthic phase

Records of mass benthic occurrences of these two species are less common, perhaps simply because they are not exposed to the view of the curious voyager; nevertheless, there are published records which indicate that they occur. Thompson (1898) records massive summer occurrences of benthic individuals of *M. subrugosa* in Otago Harbour, New Zealand, and the DISCOVERY collections include adult *M. gregaria*, trawled in abundance in 25 to 115 m of water off East Falkland Island. Cooked in the ship's galley, these were found to be of very good flavour (Matthews, 1932).

2.4 Exploitation

Neither of these two species has been utilized directly as a fishery resource, though they have been shown to be an important food of several exploited cetaceans including southern right, humpback, sei and blue whales. In addition, they are important in the diet of many rock-fish, seals and several species of sea-birds. It is to be expected that systematic trawling in sub-Antarctic waters will indicate large benthic stocks of both these species. By analogy with other species discussed below, they are unlikely to confine themselves to rocky substrates where trawling is impossible.

3 HUMBOLDT CURRENT RESOURCES

3.1 Biology

To the north of the region occupied by the two species of *Munida* described above, there occur two species which do not appear to have a postlarval pelagic phase. These are the 'langostino amarillo', *Cervimunida johni*, and the 'langostino colorado' or 'zanahoria', *Pleuroncodes monodon*, both of which have mass occurrences in the benthos off the Chilean coast. Méneville noted the occurrence of pelagic galatheids in the harbour of Callao in 1830, during the cruise of LA COQUILLE round the world (in H. Milne Edwards, 1837), but there appears to be no other evidence of a pelagic phase in these species. The Callao specimens appeared to belong to the then-valid genus *Grimothea* though Méneville's illustrations are not very satisfactory. U.S. tuna fishermen, very familiar with the pelagic phase of *P. planipes*, know of no similar form from the Peru Current, though the benthic phase of *P. monodon* appears to extend as far north as Central America.

The benthic concentrations off Chile, where they are best known, appear to be comprised of individuals of both species within the same size range. Specimens have a mean weight of about 25 g and carapace lengths ranging from about 20 to 40 mm. This is about the same size as the benthic adults of *M. gregaria* discussed above (2.1). Shrimps of commercial importance may occur on the same grounds, but usually the mass occurrences of galatheids do not appear to correspond with the most dense populations of penaeids (Mistakidis and Henriquez, 1966).

3.2 Range of benthic phase

The Chilean shrimp fishery, which includes a fishery for these two galatheids, has defined their range as extending approximately from Caldera in the north to Calbuco in the south, though the whole of this zone has not yet been properly explored (Lopez-Capont *et al.*, 1965). Within this zone, the largest concentrations of langostino appear to occur within the depth-range 125 to 200 m. In the same depth-range the abundant shrimp appears to be *Heterocarpus reedi*, although below about 150 m the galatheids overlap the range of the deep shrimp ('gamba') *Hymenopenaeus diomedeae*. Gallardo (1963), in his study of the benthic communities off the Chilean coast, recognizes a lower sublittoral zone, extending from 50 to 400 m in which the biomass is very low and in which the bottom water is very deficient in oxygen. This is the result of the well-known oxygen minimum layer (e.g. Brandhorst, 1959) of the eastern Pacific Ocean meeting the continental slope, and similar conditions appear to extend along much of Central America. They will be referred to again below in connection with the distribution of the Mexican species of Galatheidae. It appears that *P. monodon* and *C. johni* must be capable of supporting mass populations in water with dissolved oxygen values as low as 0.1 ml/l. It is noteworthy that Gallardo describes the deposits in these zones as being of soft, highly organic substrata probably derived from the sinking of diatom cells from surface blooms. These blooms are associated with the upwelling areas so typical of this coastline.

3.3. Exploitation

The fishery for these galatheids has been prosecuted since 1953, and has reached an annual catch of 10 x 10^3 tons annually (Table I).

TABLE I

The development of the Chilean 'langostino' landings (from Lopez-Capont, *et al.*, 1965)
Units = metric tons

	Total catch	Consumed fresh	Canned	Frozen tails
1953	0.93	0.29	0.59	0.47
1954	2.64	0.85	1.20	0.58
1955	2.05	0.78	1.10	-
1956	5.71	1.61	3.57	-
1957	11.38	4.27	0.73	5.82
1958	12.83	5.37	0.22	6.33
1959	6.75	0.93	0.80	5.02
1960	8.12	1.22	0.83	6.02
1961	8.15	0.62	0.65	6.89
1962	7.99	0.36	0.94	6.69
1963	9.25	0.20	0.94	7.91
1964	10.67	0.68	0.94	9.03

In the early years of the fishery the landings were generally utilized in the fresh state or as a canned product, but at the present day almost the entire landings are frozen for export. The landings comprise about 60 percent *C. johni* (Mistakidis and Henriquez, 1966), but this may not be an accurate reflection of relative abundance in the sea. *C. johni* has a slightly higher meat yield (9 to 10 percent) than has *P. monodon* (6 to 7 percent), and there may well be a preference for it in the fishery.

There is a seasonal fluctuation in the landings, which are normally highest during the first half of the year (Lopez-Capont, *et al.*, 1965). The small trawlers used in the fishery average about 0.6 ton/h, but recent surveys have shown that catch-rates may, on occasion, go much higher than this average. Maximum catch-rates, obtained during a survey to the north of Constitución (Mistakidis and Henriquez, 1966), were 4.16 ton/h at 36 to 37°N and 2.53 ton/h at 35 to 36°N.

It seems likely that this resource extends a good deal further to the north than it is currently exploited, for *P. monodon* is known to extend along the Peruvian coast as far north as the Lobos de Afurea Islands (Haig, 1955). There is even evidence of its occurrence off the west coast of Mexico, at Acapulco (Boyd, MS), though this record, together with Boyd's discussion of specific characters, suggests that the distinction between *P. monodon* and *P. planipes* requires further examination.

4 CALIFORNIA CURRENT RESOURCES

4.1 Biology

The red or pelagic crab, Pleuroncodes planipes, occurs at the southern end of the California Current and in the Gulf of California in both the benthic and pelagic phases. Mass occurrences of the pelagic phase in the surface waters are a well-known phenomenon in this region, and although it occurs at least 1,000 mi to the southwest of Baja California in the extension of the California Current, it does not appear to extend southwards along the coast of Mexico far below the mouth of the Gulf of California.

Until relatively recently the benthic phase was unknown, but it is now established that it occurs widely on the upper parts of the continental slope, both in the Gulf and along the western coast of Baja California (Boyd, MS; Parker, 1964; Perkins, personal communication). Boyd found benthic P. planipes along this coast to 26°N, while Parker found them to 28°N in Sebastian Viscaino Bay, and this appears to be their northern limit in normal years. Parker, however, found them as far as latitude 32 to 33°N, in the area of Ensenada and San Diego, during the warm year 1959 to 1960, a range extension which will be discussed below.

The data on the depths at which P. planipes have been found in the benthic phase by these three authors are consistent, as the following tabulation indicates:

	Depth (m)	T°C	O_2 (ml/l)
Boyd	75-300	10.0-14.0	0.5
Parker	64-366	9.0-14.0	0.5-2.0
Perkins	73-201	12.0-14.6	

Further ecological data on the associated fauna of stations at which P. planipes occurred, given both by Boyd and Parker, indicate that mass concentrations occur to the virtual exclusion of other forms. Parker writes of enormous numbers of Pleuroncodes (together with an unidentified species of Munida) occasionally occurring in a depth zone otherwise largely devoid of benthic organisms, and in which occurred large quantities of undecayed organic detritus at the surface of the deposits. As with the Chilean species, all benthic records of P. planipes are from depths corresponding to the oxygen minimum layer, and this is confirmed by the actual observations of oxygen concentration tabulated above. It is suggested that the mass occurrences often, or usually, occur on the deposits underneath coastal upwelling regions and other places in which diatom blooms occur. The 'rain' of Coscinodiscus and other diatom cells in these areas produces green, unoxidized muds, with a very high organic content, which are probably utilized as food by the benthic galatheids. Aquarium observations of P. planipes show that, as well as feeding as a predator on almost any organism of suitable size, it will readily feed on organic detritus lying on the bottom of the vessel. It sweeps detritus towards the mouth by the action of the fan-shaped third maxilliped.

There do not appear to be any significant morphological differences, apart from size, between pelagic and benthic individuals of this species. The pelagic phase is as regular an occurrence in the life history of P. planipes as is the grimothea stage of M. gregaria. The third maxilliped is foliaceous and the walking legs have a fringe of natatory setae in both the benthic and the pelagic phases. It seems probable that in P. planipes there can be an alternation between pelagic and benthic phases in the life of a single individual.

4.2 Range of pelagic phase

The distribution of the pelagic phase of P. planipes in the California Current is now well known, both as a result of special investigations and of the long-term plankton studies of the California Cooperative Oceanic Fisheries Investigations. Fig. 1 and 2 are derived from the latter data and indicate the frequency of occurrence of pelagic swarms in different regions off the California coast and the oceanic areas in

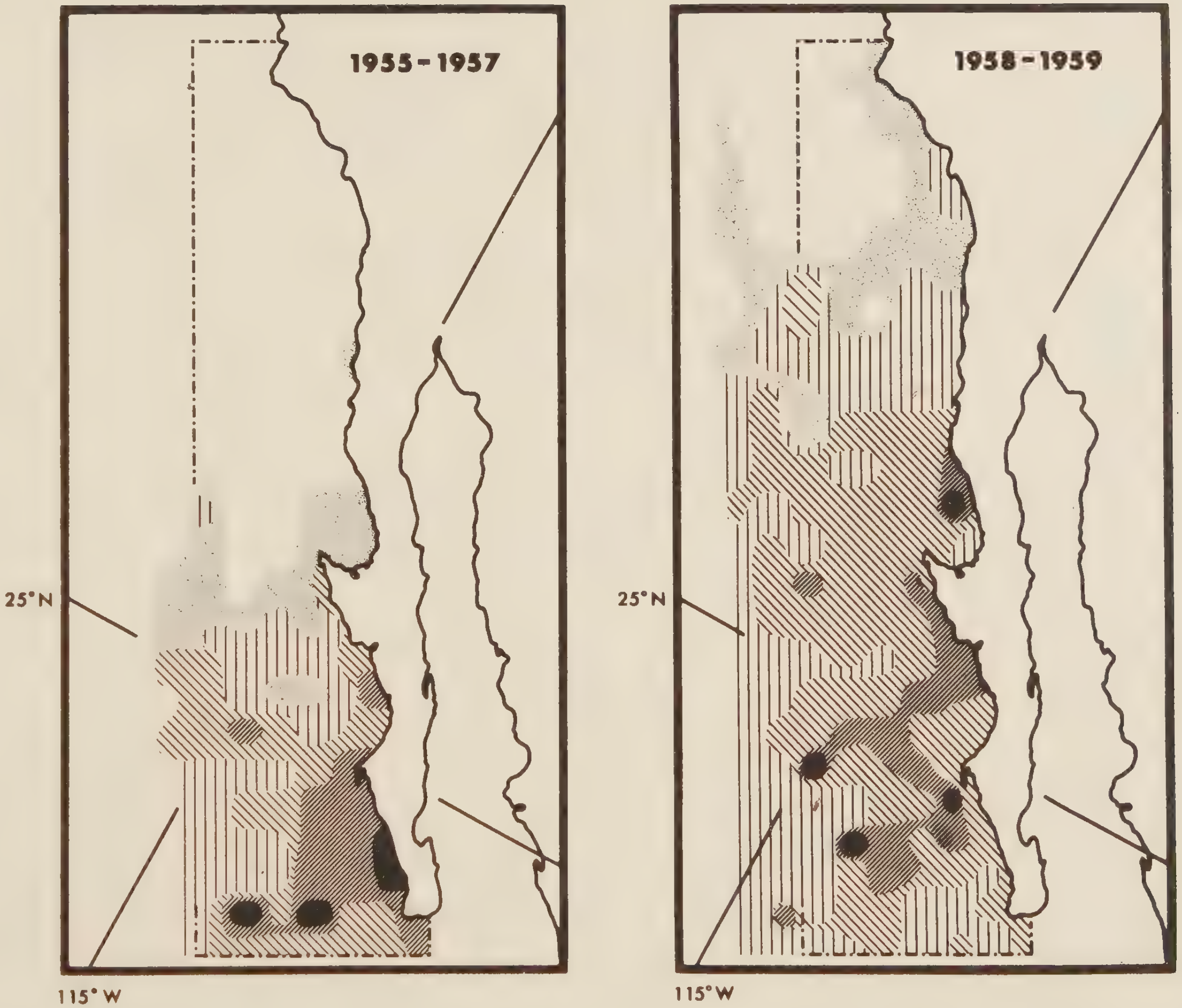

Fig. 1 Distribution of Pleuroncodes planipes in pelagic phase in California Current, expressed as percentage occurrence in plankton hauls at standard CalCOFI stations. Shaded areas (lighter to darker) represent: 1-10%, 11-25%, 26-50%, 51-75%, 76-100% occurrence.

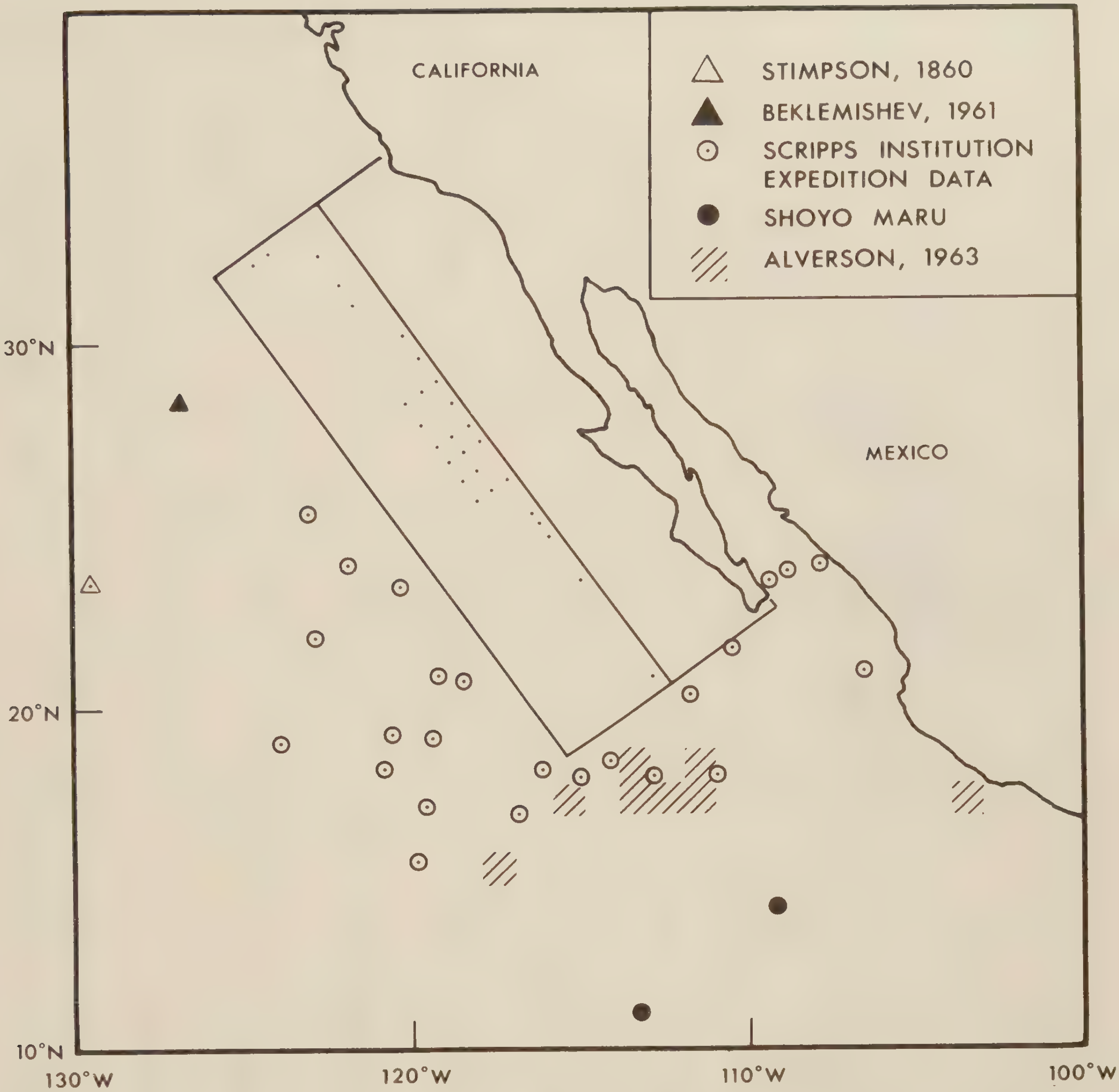

Fig. 2 Distribution of Pleuroncodes planipes in pelagic phase in offshore and oceanic regions of California Current. Coastal rectangle is area illustrated in Fig. 1; outer rectangle was sampled regularly but less frequently (occurrences indicated by dots); other records from irregular or occasional observations.

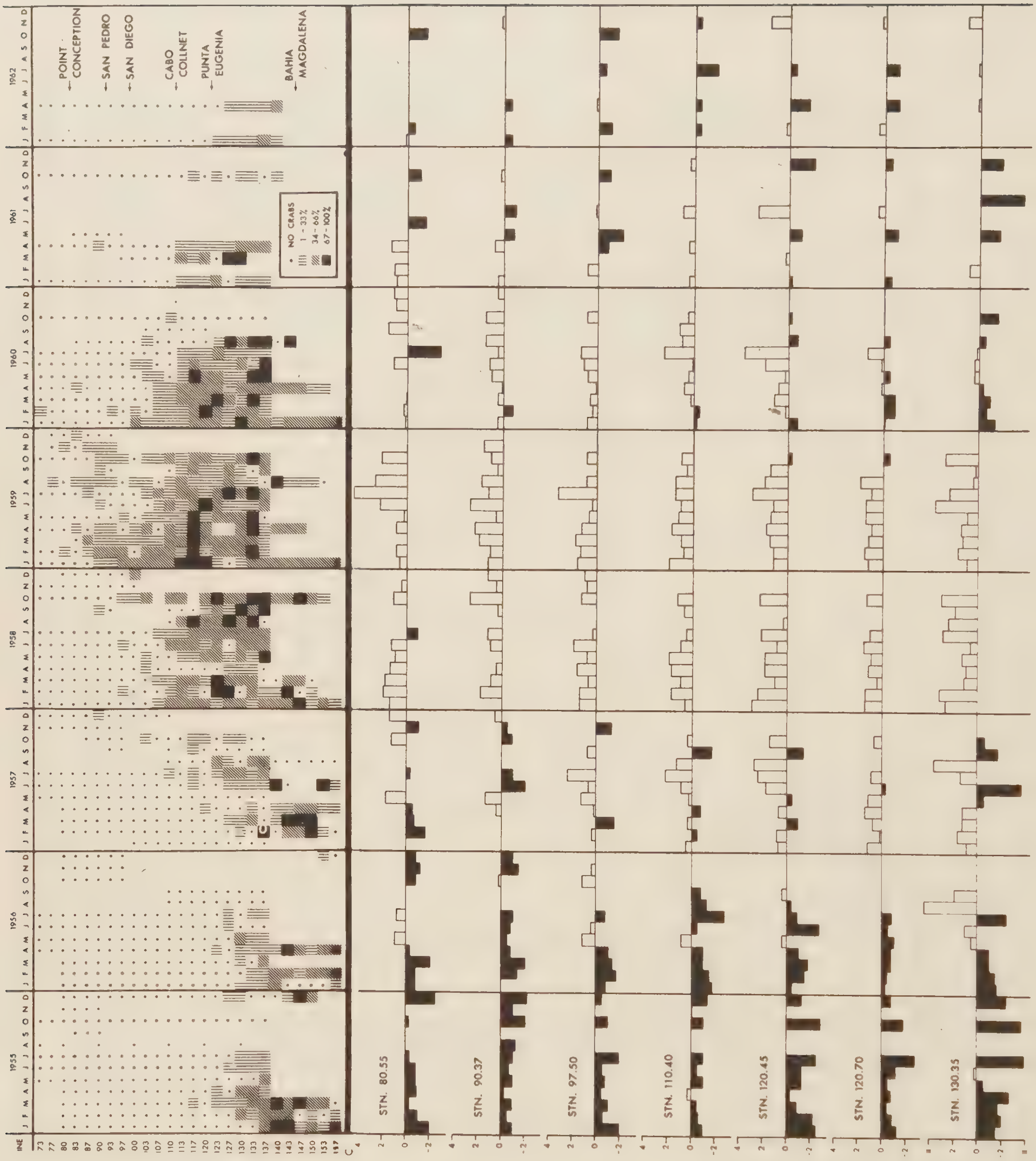

Fig. 3 Variation in distribution of pelagic Pleuroncodes planipes in 1955-1962 related to sea temperature. Numerals in top left margin represent station lines lying normal to coast in geographical sequence indicated at top right margin. Percentages are number of stations in each line at which plankton sample contained pelagic crabs in month referred to at top of figure.

Bottom part of figure shows temperature anomalies at a number of selected stations.

which smaller numbers of specimens have been recorded. The swarms appear in regions of coastal upwelling, and there is some dispersal in the waters of the offshore drift, to the southwest of the California Current.

Also indicated (Fig. 3) is the manner in which the range of the pelagic phase off the western coast of Baja California changed in response to the changing climate in the years 1955 to 1962. Pelagic crabs were recorded abundantly as far north along the Californian coast as the Monterey Peninsula in 1960. Both the range extension to the north at the start of the warming period and the regression at the end of the period can be explained (Longhurst, in press) by the changing patterns of flow in the California Current at these times, particularly the changing form of the large permanent gyre which normally exists to the south of Point Conception. During this northerly range extension, there were numerous records of windrows of pelagic *P. planipes* being swept ashore at points along the coast of California, a phenomenon which is of common occurrence along Baja California and the Gulf coasts, and which recalls the reports of strandings of *M. gregaria* described above (Glynn, 1961; Boyd, MS; Radovich, 1961; Longhurst, in press).

The problem of the relationship between the pelagic swarms and the benthic populations along the continental slope is an interesting one and hard to resolve. It is evident from the general pattern of flow at the southern end of the California Current that there is an offshore drift to the southwest in the surface waters. The distribution of the pelagic phase in oceanic areas suggests that pelagic specimens from the coastal areas of Baja California are swept offshore by this drift. The flow of the California Current is far from laminar (Reid, Schwartzlose and Brown, 1963) and sufficient eddying occurs to maintain a spat-fall of planktonic larvae of benthic organisms along the continental shelf. There is evidence, however, that the larval forms of *P. planipes* are flushed out of the Baja California centers of spawning (Fig. 4) into oceanic areas to the southwest. It has also been demonstrated (Longhurst, in press) that the pelagic postlarval forms in oceanic areas are generally smaller than those encountered in massive swarms over the continental shelf, and both these groups are generally larger than the individuals encountered in the benthic phase (Boyd, MS; Longburst, in press).

The question to be resolved, therefore, is whether or not the oceanic individuals in the pelagic phase are lost to the parent stock on the continental slope, or whether they (or a proportion of them) return to coastal areas. The evidence is conflicting: a possible mechanism for their return exists in the sub-surface currents flowing to the northeast under the California Current, and closing-net tows have shown concentrations of crabs at the right depths for such transport (Longhurst, in press), but there is recent evidence that maturity is reached by some pelagic individuals in the oceanic region and that breeding occurs there (Blackburn, personal communication). Perhaps both possibilities are partly true. It is particularly difficult to determine whether or not an alternation occurs between benthic and pelagic phases over the continental shelf, but the fact that benthic individuals retain their natatory setae is evidence for such an alternation. Individuals captured at sea in the pelagic phase are very ready to adopt a benthic existence again, and can be seen clinging to any substrate which they encounter; it is not unusual to bring one up clinging to an oceanographic instrument, they have been observed clinging to large salps in the upper few metres of water, and they settle at once in an aquarium.

4.3 Food relationships

The ability of *P. planipes* to graze directly upon blooms of phytoplankton with a major diameter in excess of 25 to 30µ has recently been demonstrated and the filtering mechanism described (Longhurst, Lorenzen and Thomas, in press). The aperture size of the filter formed by the exopodites of the third maxillipeds appears to correspond with the minimum particle size retained during experimental grazing on natural phytoplankton, and is of the order of 25µ in *Pleuroncodes* of approximately 20 mm carapace length.

Pelagic individuals can be watched at sea from an underwater observation chamber, and it can be seen that they graze by using their fan-shaped maxillipeds as a cast-net

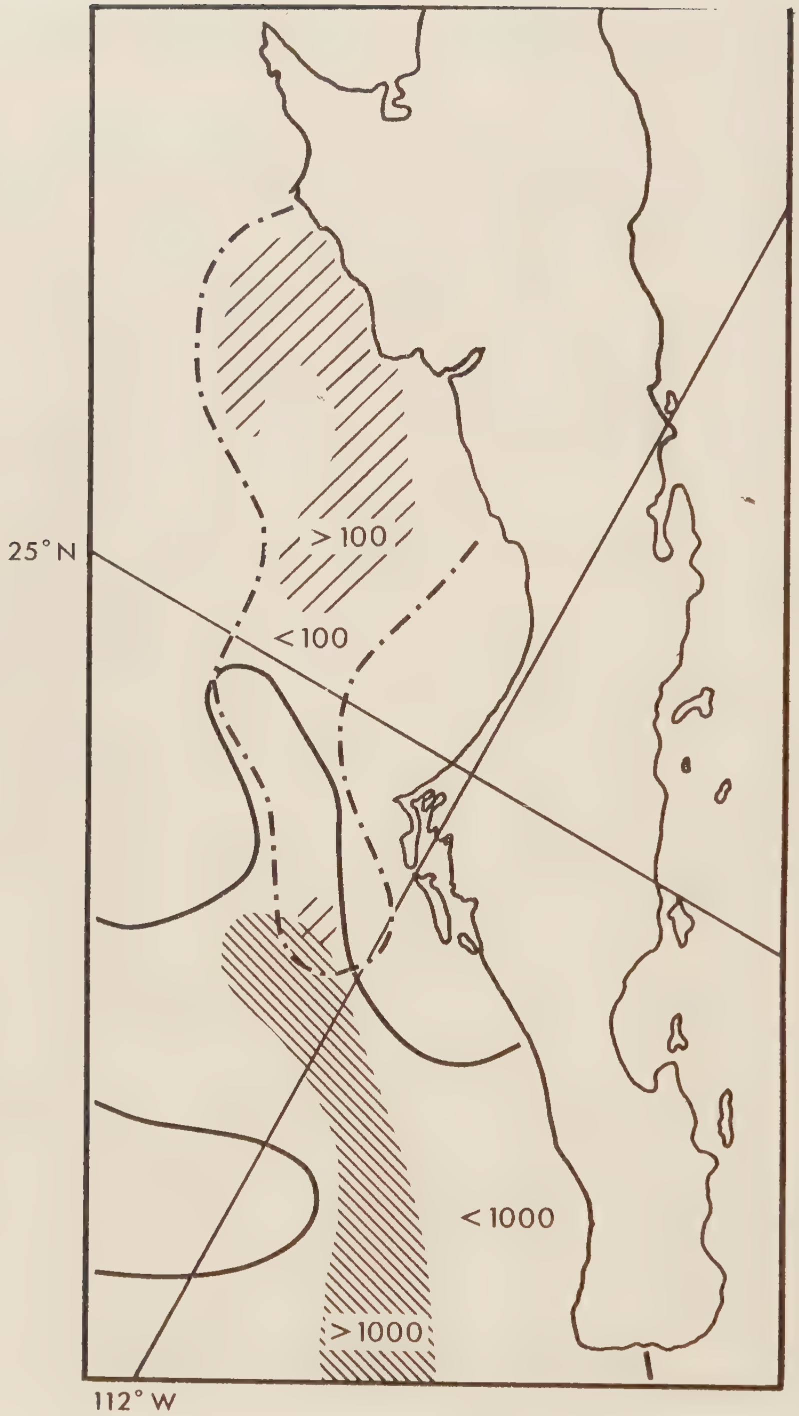

Fig. 4 Distribution of larval (dotted line) and megalopa (solid line) forms of Pleuroncodes planipes off Baja California in June 1964.

while they are sinking slowly with their legs spread out like a parachute. A grazing population comprises many individuals slowly sinking in this way, interspersed with others swimming rapidly upwards by abdominal flexure. Animals that have become accustomed to an aquarium can be induced to graze even when they are resting on the bottom.

Experimental data show that a large volume of water can be filtered during grazing. The maximum daily production of faecal pellets recorded for a freshly-caught grazing crab amounted to 102 mg dry weight and consisted of greenish material in which 5×10^5 whole undigested cells of *Coscinodiscus* were counted. Under the natural standing crop conditions observed, this would correspond to 540 l/day filtered, assuming a filtration efficiency of 100 percent and a digestive coefficient of 50 percent. Calculations based on close observation of the rate of beat of the filtering appendages produce an estimate of the maximum filtration rate of 432 l/day. The two figures are in general agreement.

The above observations were made off Baja California, and the grazing budget of the same location was monitored over a five-day period. The results suggest that herbivorous zooplankton was responsible for only about 10 to 15 percent of the observed excess of phytoplankton production over the observed standing crop, and that the stock of pelagic crabs was sufficient to be responsible for most of the remaining apparent grazing. Evidently the pelagic phase of *P. planipes* may play a very important role in the grazing of diatom blooms in coastal upwelling areas in the California Current.

The importance of *Pleuroncodes* in the diet of many predatory animals in this area is well known. The fish *Eschrichtius*, *Neothunnus*, *Thunnus*, *Katsuwonus*, *Coryphaena*, *Seriola*, and the birds *Larus*, *Phalacrocorax* and *Pelecanus* all feed actively on mass occurrences of pelagic crabs (Longhurst, Lorenzen and Thomas, in press). Alverson (1963) has demonstrated that the stomach contents of yellowfin tuna (*Neothunnus albacares*) from the region to the west of Baja California were dominated by pelagic *Pleuroncodes*; the mean volume of crabs contained in each yellowfin stomach was about 0.5 l (or about 100 crabs). This figure must be less than the average daily intake of each member of the population of tuna, and 3.99×10^6 tuna were taken by the United States fishery alone in 1960 off Baja California. This represents a daily cropping at the beginning of the season of 2×10^3 tons of *Pleuroncodes* by those fish which would be caught by the fishery in the subsequent six months or so. The quantity utilized by this single stock of predatory fish is thus very high indeed over the year as a whole.

The main ecological significance of the utilization of pelagic *Pleuroncodes* in this manner is that the food-chain is thus rendered unusually short and direct between the primary producers and the climax predators.

In the offshore oceanic environment, the pelagic crabs maintain themselves on a more varied diet than over the continental shelf. Food is obtained both by the filtration apparatus and also by selective particulate feeding by use of the chelipeds; it consists mainly of small Copepoda (*Microsetella*, *Clausocalanus*, etc) and large Protozoa (radiolarians, tintinnids), together with a few large phytoplankters such as dinoflagellates. A survey of stomach contents from a grid of stations to the west of Baja California in June 1964 showed that it was only in a relatively few localities that phytoplankton dominated the stomach contents and that these stations were situated in upwelling areas.

4.4 Breeding and growth

Breeding occurs in the California Current during the winter months, especially in the first three months of the year; this is evident from data of Boyd and Johnson (1963) on the percentage of ovigerous females in the CalCOFI plankton samples, and is confirmed by work now in progress on the distribution of larval forms in the same plankton samples. The five larval stages described by Boyd (1960) are passed through in 3 or 4 months in the laboratory (Boyd and Johnson, 1963), and this is essentially confirmed by studies on net-caught larvae.

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The work in progress indicates that breeding is concentrated at a few centers over the continental shelf, and it is presumed that these correspond with the centers of distribution of the adult crabs as a whole, including both benthic and pelagic stocks.

Growth rates of the postlarval forms have been studied both by Petersen's method on net-caught samples and in the laboratory (Boyd, MS). In general terms, a carapace length of about 20 mm is attained at the end of the first year, a little less than 30 mm at the end of the second year, and about 35 mm at the end of the third year. There are reasons to suppose that growth rates are not constant over all the ecological situations in which the species occurs. The approximate growth rates just given, however, suggest that the benthic stocks are in their second and third years of life (the deeper, the older), the pelagic stocks over the continental shelf are between 9 and 15 mo old, and the offshore oceanic stocks are within their first year of life. There may be an underestimation of the age of offshore stocks as these will be living at a lower nutritional level than the inshore stocks.

4.5 Exploitation

There has been no exploitation of this species directly, but the possibility of such exploitation is clear, and food-processing interests in California are currently studying the viability of a fishery for P. planipes.

One of the first decisions to be made in planning such a fishery is whether the exploitation should be based upon the pelagic or the benthic phase of the species, or upon both. Unfortunately, the data for an entirely rational decision do not at present exist, for no comprehensive trawling survey of the region has been completed to determine the real extent of the benthic stocks, nor their seasonal variation. One of the major problems to be solved currently is the fate of the pelagic stocks over the continental shelf which are generally considerably more abundant early in the year. Have they been flushed out to sea, have they been grazed down by the migratory tuna which arrive in the area in the spring, or have they descended and been recruited to the benthic stocks?

Blackburn (personal communication) has observed the density of pelagic swarms to be very variable, from situations where the crabs are exceedingly sparse to those in which they appear to be piled up on top of one another. During several cruises to the region of Baja California in which standard tows were made with a nekton net on a standard grid system, a total of 33 hauls collected pelagic Pleuroncodes, at a mean density of 101.7 ml of crabs per $10^3 m^3$ of water filtered. At 32 of these stations the volume of crabs was from 1 to 355 ml/$10^3 m^3$, while at one station it was 1539 ml/$10^3 m^3$; such a distribution confirms subjective observations at sea, which suggest that the most dense mass occurrences are denser by almost an order of magnitude than the 'background' occurrences of pelagic individuals. It can be supposed, therefore, that by searching it would be possible to find concentrations that would yield 250 kg/h with a small pelagic trawl; this figure is based on a mouth aperture of $30 m^2$, a towing speed of 5.4 km/h, and a filtration efficiency of 100 percent. This figure is likely to be an underestimate, since the density of individuals on which it is based was taken from a net worked on a standard oblique haul to 200 m depth and which was not held at the depth at which crabs were seen or thought to be aggregated. My observations at sea suggest that, at times, it would be possible to exceed this figure by a factor of ten, by selective fishing with such a net.

The data of Boyd (MS), Parker (1964) and Perkins (personal communication) on the benthic phase include some estimations of the population density of individuals. Using a swept area method based on the catch of a trawl having an aperture approximately 3 m wide, Boyd suggested that the average density at one station was of the order of 10 Pleuroncodes per m^2 on the deposits. Extrapolating to a commercial otter trawl of 10 m across the mouth and a towing speed of 5.4 km/h, this implies a catch rate of 13.5 x 10^3 kg/h, assuming a catching efficiency similar to that of Boyd's 3 m trawl. At such a high catch rate it would be impossible to tow a demersal trawl for as long as one hour without it so filling with crabs as to be torn or lost altogether. This has, in fact, been the experience of a trawling survey along the west coast of Baja California. Perkins (personal communication) found that during a trawling survey for demersal fish along the continental shelf it was impracticable to trawl deeper than about 150 m along much of the coastline since the trawl rapidly filled with benthic Pleuroncodes and became unmanageable. This first estimate of likely catch rates in a demersal fishery for Pleuroncodes cannot be more than preliminary, and may be considerably modified by a properly conducted survey of the benthic crab resources, and such a survey is urgently required before any rational planning of a fishery can take place. In any case, the available evidence suggests that catch rates at least as high as those which prove to be economically feasible in the Chilean fishery may be obtained off Baja California.

5 POTENTIAL OF THE RESOURCES

As part of the FAO participation in the Indicative World Plan for Agricultural Development, estimates of the total potential yield from fisheries resources are required, and it is interesting to postulate what might be the long-term annual yield from the utilization of mass occurrences of galatheids. The estimate is restricted to the three regions discussed here, and ignores any further stocks which may in the future be identified in other eutrophic ocean areas. It leans rather heavily on the figure of 10×10^3 tons for the present annual landings of the Chilean fishery and assumes approximately equivalent biology and size of individuals in the various species concerned. It is suggested that the potential yield is most unlikely to be less than 30×10^3 tons per annum. It may be higher than this figure: a factor of ten times seems subjectively just possible, while a factor of one hundred seems impossible. It is suggested therefore that the ultimate yield from the stocks considered here will be found to lie between 30×10^3 and 300×10^3 tons per annum. To attempt a narrower estimate than this would be quite unrealistic, in our present state of ignorance about the real extent of the benthic stocks of two of the five species under consideration.

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A REVIEW OF THE CULTURE OF SUGPO, *Penaeus monodon* FABRICIUS, IN THE PHILIPPINES

by

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Abstract

The culturing of sugpo (*Penaeus monodon* Fabricius) in the Philippines has been carried out for a very long time in association with the culturing of bañgos (*Chanos chanos*). They were grown simultaneously in the same fishponds, with sugpo as a secondary product; it was never raised alone. With the exploitation of the sugpo fry fishery, the more lucrative business of pure sugpo culture has developed.

The sugpo fry are caught commercially along the shores of Manila Bay from the early part of May until the end of October or early November, but in other places the fry enter fishponds with the incoming high tide. Different methods of catching fry, the selection of a site for cultivation, the construction and preparation of a pond, and the raising and harvesting of sugpo are described.

In spite of problems encountered in the culturing of sugpo, a comparison of the production of a pure bañgos culture, a mixed bañgos and sugpo culture, and a pure sugpo culture, shows that the latter gives the highest net income.

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RAPPORT SUR L'ELEVAGE DE *Penaeus monodon* FABRICIUS ("sugpo") AUX PHILIPPINES

Résumé

Aux Philippines, l'élevage de la crevette *Penaeus monodon* Fabricius ("sugpo") s'est très longtemps pratiqué en association avec celui des poissons *Chanos chanos* ("bañgos"). Ces deux animaux étaient élevés simultanément dans les mêmes étangs. Les crevettes représentaient une production secondaire et n'avaient jamais été élevées seules. Avec le développement des captures du frai de "sugpo", l'élevage plus lucratif des seules crevettes a pris de l'expansion.

Le frai des crevettes est pêché commercialement le long des côtes de la baie de Manille depuis le début de mai jusqu'à la fin d'octobre ou au début de novembre; ailleurs, il est apporté dans les étangs de pisciculture par la marée haute. Les auteurs donnent des indications sur différentes méthodes de récolte du frai, sur le choix des lieux d'élevage, sur la construction et la préparation des étangs, ainsi que sur l'élevage et la pêche des crevettes.

Malgré les problèmes que pose l'élevage des crevettes, une comparaison entre l'élevage pur des bañgos, l'élevage mixte bañgos-crevettes et l'élevage pur de crevettes montre que celui-ci assure les revenus les plus élevés.

EL CULTIVO DE SUGPO, *Penaeus monodon* FABRICIUS, EN LAS FILIPINAS

Extracto

El cultivo del sugpo (*Penaeus monodon* Fabricius) en las Filipinas se viene realizando desde hace mucho tiempo junto con el cultivo de sabalote o bango (*Chanos chanos*). Ambos se criaron simultáneamente en los mismos estanques piscícolas, con el sugpo como producto secundario; no se ha efectuado nunca la cría de éste aisladamente. Con la explotación de la pesquería de crías de sugpo se ha desarrollado el negocio más lucrativo del cultivo puro de sugpo.

Las crías de sugpo se capturan comercialmente a lo largo de las costas de la bahía de Manila desde principios de mayo hasta finales de octubre o primeros de noviembre, pero en otros lugares aquéllas entran en los estanques piscícolas con la marea alta. Se describen diferentes métodos de captura de las crías, la selección de los lugares apropiados para el cultivo, la construcción y preparación de los estanques y la cría y recogida de sugpo.

A pesar de los problemas con que se ha tropezado para el cultivo de sugpo, una comparación de la producción del cultivo único de bango, del cultivo mixto de éste y sugpo, y del cultivo único de este último, indican que el sugpo proporciona los mayores ingresos netos.

1 INTRODUCTION

The culturing of sugpo (Penaeus monodon Fabricius) in the Philippines is as old as the culturing of bañgos (Chanos chanos Forskal), but sugpo was grown as a secondary product and was never raised alone. In many places in the Philippines, as in Mindanao and parts of southern Luzon where ponds are established near the probable breeding places of prawns, the fry just enter the fishponds and are continuously harvested.

Since sugpo fry are readily recognizable from other fry, their collection and commercial exploitation was developed and led to the sugpo fry fishery. This is now a distinct and lucrative fishery in many places in the Philippines, especially in the coastal towns of Cavite and Batangas, where they are caught from May to October.

Villadolid and Villaluz (MS) described the cultivation of sugpo with bañgos and separately.

2 SUGPO FRY FISHERY

2.1 Appearance and size

The sugpo fry generally appear along the shores of Manila Bay in the early part of May and continue until the end of October, sometimes extending to the early part of November. They are easily distinguishable by the dark brown pigment running through their transparent bodies, thus making them appear like small pieces of broken stick or debris. They usually measure from 10.0 to 15.2 mm. Delmendo and Rabanal (1956) gave the length of fry as 15.3 mm, but the latest sugpo fry surveys in Ternate, Cavite, (Caces-Borja, MS) have revealed some as small as 8 mm, much smaller than previously reported.

2.2 Fishing grounds

The fry are caught in almost all places in the Philippines where bañgos fry are found. In the northern parts of Luzon, sugpo fry appear rather later than the bañgos fry. The practice in the region is to gather the sugpo fry only when there is a demand for it.

Sugpo fry can also be found in tidal rivers, creeks, lagoons, and other shallow places with brackish water where they are brought in by the incoming high tide. They have been found attached to masses of drifting seaweeds. They also cling to various aquatic plants, such as the water hyacinth and lily, and semiaquatic plants of the family Gramineae which grow in swampy places below the tideline. They are found particularly after storms, which usually occur in the months of June, July and August. The sugpo fry migrate to the shore and into brackish waters for feeding and shelter. They remain in these places for not less than 6 mo, after which they return to the sea to spawn.

The Maragondon River contains fry of various sizes, and some early adults of up to 80 mm are caught further up the river, showing that the fry metamorphose in the river (Caces-Borja, MS). This is the largest river emptying into Manila Bay and apparently attracts and accumulates fry in their fresh water migration after having been hatched in the deeper, more saline waters just outside the Bay. Fig. 1 shows the Maragondon River, with its mouth in Manila Bay divided by Balut Island. The peak of the fry season occurs during the months of September and October with the northeast monsoon.

All along the western coast of Luzon, sugpo fry are found during the bañgos fry season.

The most important sugpo fry grounds surveyed by the Agricultural Department of the Development Bank of the Philippines are listed below:

(i) Dagatdagatan Lagoon, Malabon, Rizal Province

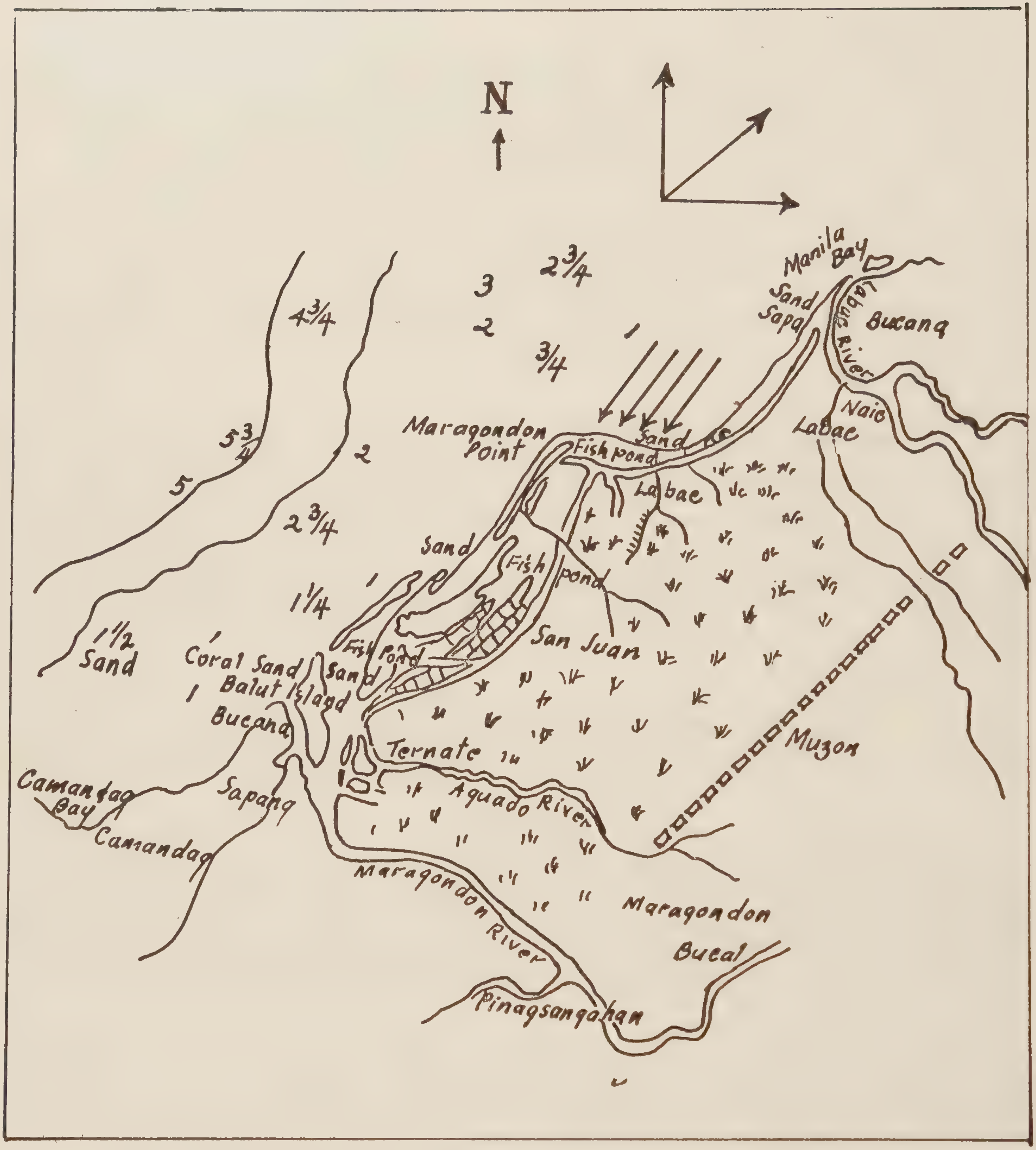

Fig. 1 Map of a portion of Manila Bay showing the Maragondon River where there is an abundance of sugpo fry.

(ii) Dongalo River, San Dionisio, Parañaque, Rizal Province

(iii) Binuangan River between Tanza, Navotas, Rizal and Obando, Bulacan

(iv) Mabolo River and Nalamok in Bacoor Bay and in Salinas, Tanza, Cavite Province

(v) Binangbang River and other tributaries along the shores of Balayan Bay and along the shores of Sta. Clara, Batangas, Batangas Province

(vi) Tributaries along the shores of Pagbilao Bay and Tayabas Bay, Quezon Province

(vii) Tributaries along the shores of Pitogo and Macalelon, Quezon Province

(viii) Cabilihan River extending from Guinayangan, Tagkawayan and Calauag, Quezon Province.

2.3 Collection and marketing

Sugpo fry are caught in several ways. The use of fish lures, locally called "bon-bon", is an easy method. The "bon-bon" is made of bundles of twigs or grasses tied to a long line of rattan, wire, or string at intervals of about 1 to 2 m. The common species used for this purpose is a salt-water grass, Paspalum vaginatum. Several lines of these lures are set up in the water by tying the opposite ends to wooden poles near the bank of the river at intervals of 10 to 20 m. The fry collectors then visit their lures and place their dip net beneath each bundle of grass. They raise and shake each bundle to catch the clinging sugpo fry into the net. Some experienced collectors are able to gather as many as 10 fry from one bundle at a time. During the peak of the season, one could gather as many as 1,000 fry in 1 h. Collections are also done at night with the use of flashlights. This is the usual method employed in the provinces of Batangas, Cavite and Rizal (Fig. 2).

Another method is by dip net. The collector gathers the fry by dipping a triangular net into the water, while sitting in his wooden 'banca' or dugout. From the net the fry are transferred to an earthenware jar by scooping them up with a white porcelain bowl. The jar is provided with a few shredded banana leaves for the sugpo fry to cling to. Fry are collected at least twice a day, regardless of the tide or weather (Fig.3).

Some collectors sort their fry during collection to remove unwanted species and store the sugpo fry in lots of 100 to 250 in earthenware pots. The fry are later distributed to fishpond owners. The old practice was to transport fry in the same pots in which they were stored, but now the use of plastic bags is very popular because of their handiness and light weight (Caces-Borja, MS). These bags are half-filled with sea water and closed with elastic bands at the mouth. Then they are packed into 'buri' bags for easier handling. When they have to be transported for longer distances, the bags are aerated by the use of a bicycle pump.

The fry are sold at P13 to P35 per thousand depending on their abundance.[1] During the height of the fry season in Ternate, Cavite, the price is as low as P13 per thousand. In Batangas, the sugpo fry dealers maintain their price of P25 per thousand throughout the whole season. In Dasol, Agno and Bolinao, Pangasinan Province, sugpo fry sells from P20 to P30 per thousand, with the peak price in August and September. This is the only place in northern Luzon where the catching of sugpo fry is commercialized. In La Union, there is no pure sugpo fry business; they are caught along with the bangos fry during the months of February to July, and sell for only P10 per thousand.

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[1] 3.86 Philippine pesos (P) = 1 U.S. dollar (January 1967)

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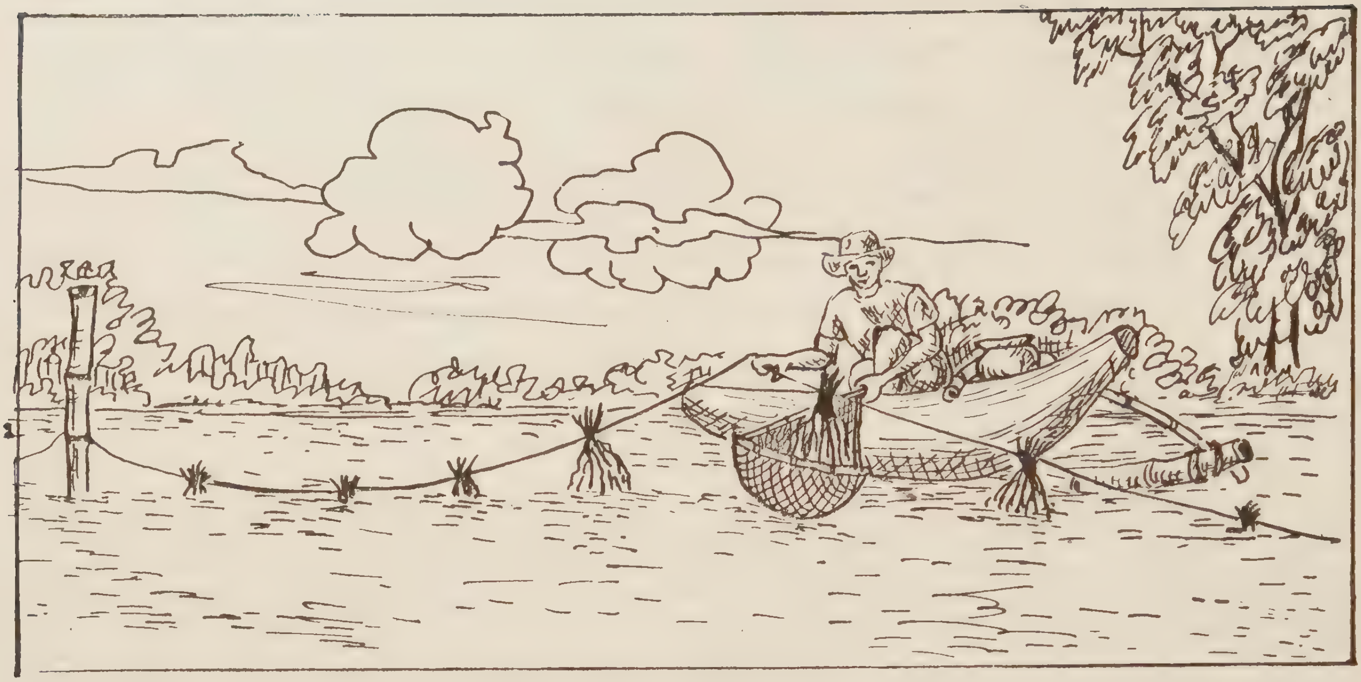

Fig. 2 The 'bon-bon' method of catching sugpo fry.

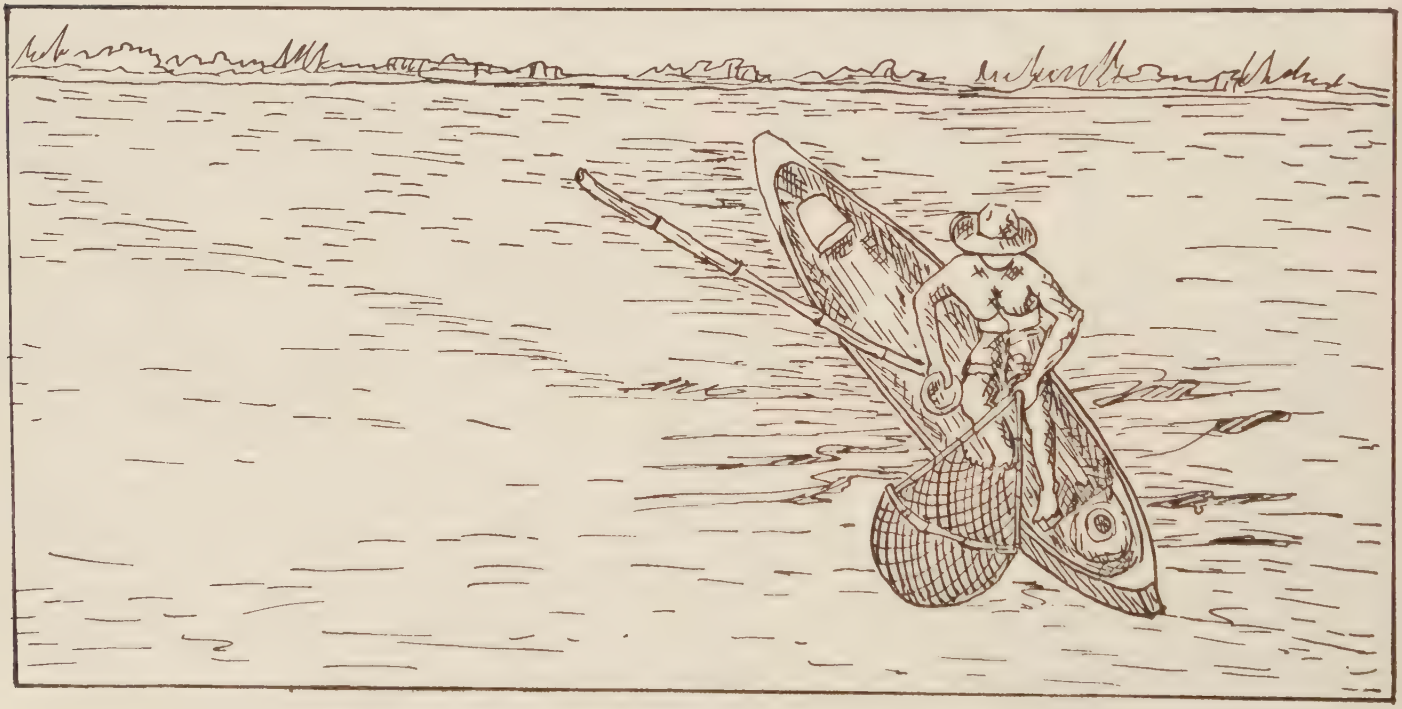

Fig. 3 The dip-net method of catching sugpo fry.

3 CULTIVATION OF SUGPO

3.1 Selecting the site

Surveys made in 1965 on behalf of the Development Bank of the Philippines in cooperation with private fishpond operators have studied current fishpond practices in the cultivation of sugpo. The report notes the following important factors to be considered in the selection of a fishpond site:

(i) Source of water

The availability of water supply is very important. There should be an available supply of fresh, brackish and salt water, depending upon the stage of growth of the shrimp. Fresh water has been found more favorable during the early stages of development, while brackish to saline waters are conducive to faster growth in the later stages.

(ii) Type of soil

Areas with sandy clay to clay loam are preferable for construction and for good growth of algal food, while sandy clay suits the creeping and burrowing habit of the sugpo.

(iii) Elevation

The area should be within the reach of ordinary tides to be easily filled to a depth of at least 3 ft. Ponds with elevated bottom should be excavated so that they could be filled during the dry season when tides are low.

3.2 Constructing the pond

Delmendo and Rabanal (1956) described a model layout for a 10 ha Penaeus pond project as shown in Fig. 4. The whole area is enclosed by a main dike with a concrete main water control gate (mg), of double-opening type, placed at a point easily accessible to the main portion. This should open into a head pond (hp), which should be the deepest portion of the system.

The whole area may be partitioned into the head pond (hp), two nursery ponds (np), together occupying 1 ha, and two rearing ponds (rp) of 4.5 ha each. The rearing ponds open to the head pond by two secondary gates (sg).

The entire fishpond system should be so levelled that the bottom gradually slopes from the periphery to the head pond and to the main water control gate. A system of special depressions or canals is constructed in each nursery and rearing pond, running from the periphery towards the head pond, through the secondary gates, as indicated in Fig. 4. These canals facilitate harvesting.

3.3 Preparing the ponds

Villadolid and Villaluz (MS) described the preparation of a sugpo fry nursery pond, usually the smallest compartment in a brackish-water fishpond system. Each pond is built with wooden gates, 1.5 to 2 ft (0.5 to 0.7 m) wide, provided with wooden slabs for water control, and with fine-meshed bamboo screens covered with abaca cloth (sinamay) to prevent the entrance and exit of sugpo fry as well as predatory species. Current practices make use of nylon screens instead of sinamay for durability. After cleaning and levelling the bottom, the nursery ponds are dried for a period of 4 to 6 wk, depending on weather conditions. Then, tidal water is let into the pond to a height of from 3 to 10 cm to induce the growth of 'lab-lab' (microbenthos) which will serve as the food of the young fry. New tidal water is let in to maintain the original height of the water. In about a month the nursery pond is ready for stocking.

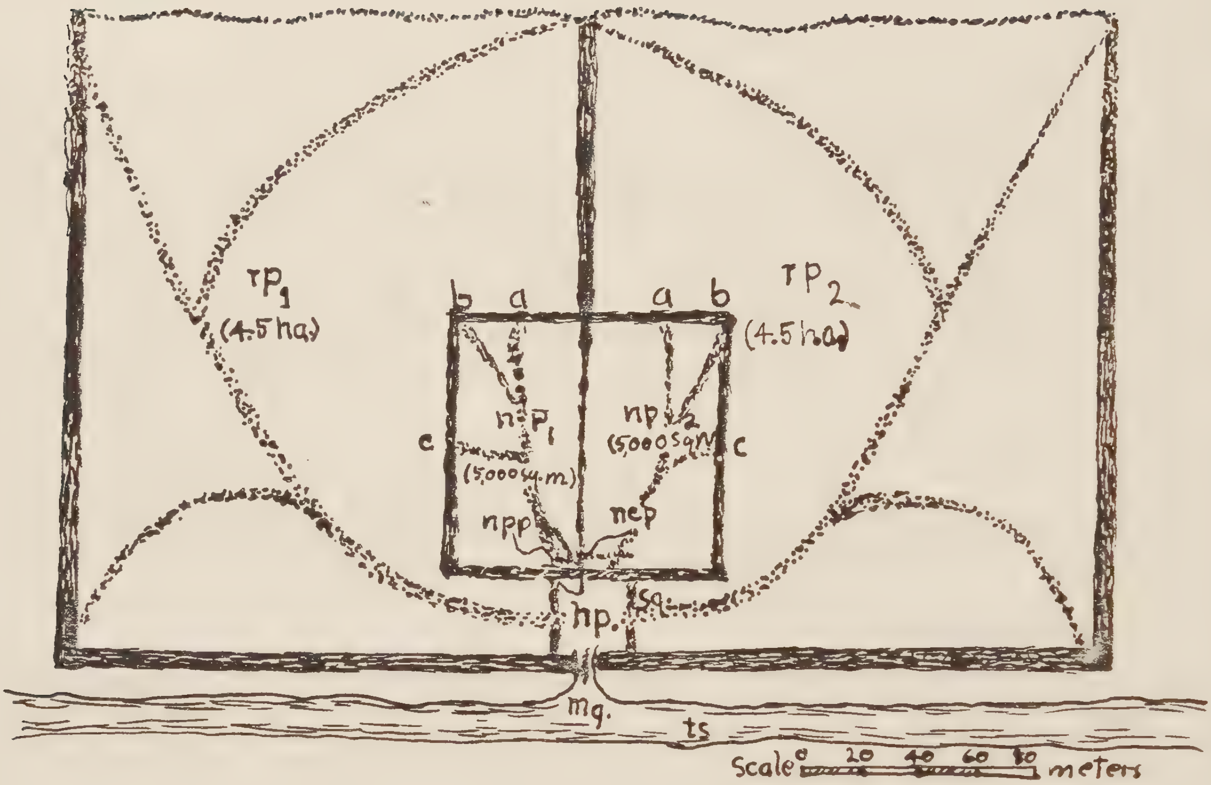

Fig. 4 Model layout for a 10 ha Penaeus pond project.

Delmendo and Rabanal (1956) stated that there was no standard method of raising sugpo in ponds. Shrimp cultivation is generally considered as a supplementary source of income and seldom are special ponds set apart for this purpose. However, the best results have been observed to stem from previously prepared nursery ponds for sugpo. The preparation of these nurseries for sugpo follows the same procedure as in Chanos culture, that is by cleaning, levelling, draining and drying the bottom. Then 'lab-lab' is grown on the pond bottom, and the pond is ready for stocking.

Current fishpond practices give great importance to the preparation of the ponds. According to technical information from the Development Bank of the Philippines, which gives loans for sugpo culture, things to be done are:

(i) Clearing

The fishpond should be cleared of unnecessary vegetation to assure maximum sunshine to enhance better growth of both the bluegreen algae (included in 'lab-lab') and the filamentous green algae ('lumut'). Short branches and twigs of swamp trees should be installed on the pond bottom to provide shelter or refuge from enemies as well as a place for attachment.

(ii) Gates and dikes

The area should be provided with a strong concrete main gate, so that tidal water may frequently be allowed to flow in and out of the ponds to provide aeration, especially in the evenings. The area should be surrounded by a sturdy main dike capable of withstanding water pressure while maintaining 3 ft (0.9 m) of water within the ponds. Provisions for proper installation of bamboo screens ('baklad pahasang') should be made with nylon or sinamay nettings whenever necessary to prevent the possible escape of stock and the entrance of predatory species.

(iii) Levelling, liming and fertilizing the pond soil

The entire fishpond bottom should be levelled in such a way that it slopes gradually from the periphery toward the water control gate. The liming of the pond bottom at the rate of at least 10 bags of agricultural lime per ha is needed to obtain good results in sugpo culture. The lime serves to absorb excess carbon dioxide in the water, as well as to supply the necessary calcium needed by the shrimps, especially during their molting periods. Fertilization with inorganic commercial fertilizers may be practised but not with organic manures.

(iv) Eradication of predators

It is necessary to clear the ponds thoroughly of predatory species before stocking, because sugpo are prey to carnivorous fishes and other predators due to their clinging and sluggish habits. Methods have been described by Villadolid and Villaluz (MS) and Delmendo and Rabanal (1956).

3.4 Raising the sugpo

Two ways of culturing sugpo are employed: (i) the usual way of a mixed culture with bangos, and (ii) the more recent way of pure culture, i.e. only sugpo fry are stocked in the ponds.

In a mixed culture, the sugpo fry are planted in a pond that has already a stock of bangos fry. This is to prevent predation on the bangos fry. Stocking is done during the cooler part of the day in order to minimize the effect of a sudden change in temperature.

Pure culture is being practised by a few fishpond owners operating large areas of fishponds. In stocking the fry, care is taken to distribute them as evenly as possible over the pond. Sugpo fry, when newly stocked in a pond, do not wander about immediately in search of food. They remain where they are liberated and become easy prey to any predaceous species that might come upon them.

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The stocking rate in the nursery pond is 300,000 to 500,000 fry to 1 ha in pure culture. In the rearing pond, the rate of stocking depends upon the availability of food. The fry are kept in the nurseries for a period of 1 to 1½ mo, after which they are transferred to the rearing ponds. A pond with good growth of 'lab-lab' and provided with supplementary feed of animal protein can be stocked with 2 sugpo per m^2, or 20,000 per ha. However, the ordinary practice of fishpond owners is to stock the rearing ponds with 1 sugpo per m^2, or 10,000 per ha.

The food of the sugpo consists of 'lab-lab', a biological association of minute plants and animals growing on the mud floor of fishponds. Rabanal (1952) made a comprehensive analysis of the components of 'lab-lab', identifying many types of fungi, bacteria, diatoms, algae and small animals.

In addition to the 'lab-lab', supplementary feeds are given. These consist of dead fish, dead animals and small crabs, which are ground into meal and piled in a corner of the pond. This serves partly as food and the unconsumed portion serves as fertilizer. Another method of supplementary feeding is to dip miscellaneous small fishes in boiling sea water, to soften the flesh, and place along the sides of the dike where the sugpo start feeding late in the afternoon or evening.

Rice bran is also used as a supplementary food for the sugpo fry. Filamentous algae are not allowed to grow in the nursery ponds, to prevent entanglement of the fry among the filaments. Instead, small bundles of dried twigs are placed to provide something for the fry to cling to during their early weeks of life. Sampling is also made easy by simply raising the twigs and collecting the attached fry. Villadolid and Villaluz (MS) stated that after the sugpo have attained a length of about 54 mm they lose their clinging instinct.

After a period of 1 to 2 mo, during which the sugpo fry have grown to a size that can be transplanted to the bigger rearing ponds, shrimp traps are set to catch the sugpo. These traps are made of bamboo screens of 'baklad' set in the pond bottom. There is a leader or guide screen, a forechamber, and a catching chamber or cod end. The shrimps seem to have no schooling habits and do not all enter the traps. Those left are picked out of the mud, after draining the pond slowly to allow the shrimps to go to the deeper areas. The young sugpo are now transferred to the bigger rearing ponds. In cases where the nurseries are adjacent to the rearing ponds, a portion of the dike that separates the ponds is opened and the sugpo are driven through the opening by disturbing the pond and scaring them. The rearing ponds are provided with 'lumot' or filamentous green algae which serve as the food for the bañgos and the sugpo.

Studies being undertaken by the Philippine Fisheries Commission on the food of the sugpo have shown a better growth and higher survival rate among sugpo fed with fish flesh in different forms, i.e. raw, blanched or powdered. Although the data gathered in these feeding experiments have not been thoroughly analyzed, a cursory inspection of the results showed a greater size increase in those with animal protein in their diet than those fed only with the natural food in the fishpond.

The sugpo under cultivation attain marketable size in a period ranging from 5 mo to 1 yr.

A study on the rate of growth of sugpo in ponds was undertaken at the Dagatdagatan Salt-Water Fishery Experimental Station, Malabon-Navotas, Rizal, covering the periods from September 1943 to April 1944 and September 1950 to August 1952 (Delmendo and Rabanal, 1956). It showed that the sugpo which had been raised in ponds for 1 yr measured on the average 229.8 mm in total length and 32.0 mm in body depth and weighed 95.1 g. The largest specimens of this age may, however, be as long as 250 mm and weigh about 120 g, while others may be as small as 180 mm long with a weight of 50 g. A kg of 1 yr old sugpo may contain 8 to 20 individuals. Table I shows the average rate of growth of Penaeus monodon under cultivation.

TABLE I

Average rate of growth of Penaeus monodon under cultivation

Duration of Culture	Total length (mm)	Body depth (mm)	Weight (g)
Fry	15.3	1.6	0.025
1 week	21.5	2.5	0.06
2 weeks	28.2	3.6	0.08
3 weeks	38.8	4.5	0.92
4 weeks	45.3	5.7	0.78
5 weeks	57.1	7.8	1.63
6 weeks	60.3	9.7	3.39
7 weeks	69.5	10.9	4.36
2 months	79.0	9.8	4.34
3 months	94.7	11.1	6.88
4 months	120.0	15.3	14.5
6 months	141.9	18.3	22.3
7 months	152.6	16.4	25.1
9 months	178.0	27.8	57.3
10 months	211.6	30.2	62.8
11 months	223.0	32.0	70.7
1 year	229.8	32.0	95.1

3.5 Harvesting

Harvesting the marketable sugpo from the rearing ponds is a difficult job because of their burrowing habit and non-gregarious instinct. Some loss is suffered in this operation because of their habits, although different methods of capture are employed to minimize this loss.

Delmendo and Rabanal (1956) described three different types of bamboo screen traps, namely the 'bakikong', the 'paabang' and the 'aguila'.

The 'bakikong' has a leader consisting of 1 or 2 bamboo screens staked and oriented perpendicularly or diagonally from the pond dike which leads the shrimp to a forechamber from which the shrimps are led into the cod end or catching chamber. A light is installed in the catching chamber at night to attract more catch. This type is especially effective during dark nights, particularly if there is water movement caused by renewal or draining.

The 'paabang' consists of the catching chamber, which is centrally located, and 2 wings to screen the water passage. This is set to intercept the shrimp at some narrow gap in the fishpond system. This type is especially designed for dark nights and when strong currents of water can be made to flow through the passage where they are set.

The 'aguila' is a modification of the 'bakikong' consisting of a leader, comparatively longer than that of the 'bakikong' and 2 chambers strategically located at both sides at the end of the leader. This is set in the deepest portion of the pond and the catch is more or less continuous regardless of the time of day or night or whether or not the flow is regulated.

Besides the bamboo screen traps, net traps are also used. A bag net of coarse cotton twine, mounted on a wooden frame, fitting into special grooves in the gate, has come into general use in the cropping of shrimps in ponds. This net is called the 'lumpot'. It is a sort of bag net tapering to an open end which is closed by tying with a piece of string. It is usually set at the main control gate, the water being previously raised to the maximum height at high tide. Thereafter, at sundown the water is allowed to go out with great force. The shrimps are carried by the current . the end of the bag where they are collected from time to time by a man stationed on a dugout canoe.

4 PROBLEMS OF SUGPO CULTIVATION

4.1 Lack of fry

The most important problem facing the sugpo industry is the apparent lack of fry for stocking. The known sources of sugpo fry are good only for certain months of the year and are not enough to meet the demands of fishpond operators. This is the main reason why many operators will not venture into the pure culture of sugpo.

A preliminary survey of the sugpo fry resources in the country shows a seasonal abundance of fry in certain areas. However, the fishery is not always exploited for several reasons:

(i) There is no market; these places are often out of reach of operators and are not generally known

(ii) The people in the community lack the technical skill for gathering or collecting fry

(iii) The people in the community are engaged in other occupations like rice-farming

(iv) Sugpo fry cannot be recognized from other kinds of shrimp

4.2 Low rate of survival

A second problem is the low rate of survival of the sugpo. On average, the rate of survival, based on the amount of marketable sugpo recovered from fishponds, is 20 percent. This could be due to the food, presence of predators, natural mortality or the non-recovery of some due to their burrowing habits. Some fishpond operators, however, have recovered as much as 60 percent from rearing ponds stocked at 10,000 fry per ha. These operators have given supplementary feeds to their stock.

4.3 Difficulty of cropping

A third problem is the difficulty of cropping. During cultivation, the sugpo are cropped twice, i.e. at the time of transfer from nursery to rearing ponds and at harvest time for the market. The methods employed are not yet good enough to effect a total catch because of the burrowing and non-gregarious habits of the sugpo. These have still to be improved.

5 COMPARATIVE PRODUCTION

Observations made by technical men of the Development Bank of the Philippines, Agricultural Department, on actual practices in the cultivation of sugpo, show that 1 ha of nursery pond with sufficient food supply can accommodate as much as 500,000 sugpo fry. In the rearing pond, the rate of stocking should be 1 sugpo for every m^2 or at least 10,000 sugpo per ha in the case of pure culture of sugpo, and 1 sugpo for every 2 m^2 in the case of a mixed culture of bangos and sugpo.

Assuming 50 percent survival from the time of cultivation in the rearing pond to the time they are harvested, 1 ha of fishpond (in the case of pure culture of sugpo) can yield about 5,000 marketable sugpo, equivalent to 250 kg (20 to 1kg) valued at P1,250 based on the wholesale price of P5.00 per kg.

In a mixed culture of bañgos and sugpo, 1 ha of pond will yield about 1,000 marketable sugpo (based on 20 percent survival) equivalent to 100 kg valued at P500.00 (based on P5.00 per kg).

TABLE II

Comparative production from 1 ha fishpond using the three types of cultivation
(i) bañgos alone, (ii) bañgos + sugpo, (iii) sugpo alone
Average cost per kg of bañgos is P1.80 whereas 1 kg of sugpo costs P5.00

Types of culture		Intensity of stock	Cost of stock (Pesos)	Survival	Production (kg)	Value (Pesos)
(i)	Bañgos	1,500	90.00	1,000	333	599.40
(ii)	Bañgos	1,000	60.00	666	220	396.00
	Sugpo	5,000	150.00	1,000	100	500.00
(iii)	Sugpo	10,000	300.00	5,000	250	1,250.00

Table II shows the comparative production yield from 1 ha of fishpond with respect to the three types of cultivation, namely: (i) pure culture of bañgos, (ii) mixed culture of sugpo and bañgos, and (iii) pure culture of sugpo.

With the cost of 1 sugpo ranging from P0.02 (fry stage) to P0.05 (juvenile stage), marketable-sized sugpo cost from P3.50 to P6.50 per kg, depending on their quality and size. The market value is highest during the Holy Week and Christmas seasons, when 1 kg costs from P7.50 to P9.00. A pure culture of sugpo would certainly give a bigger annual income than either a mixed culture of bañgos and sugpo or a pure culture of bañgos alone.

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TECHNIQUES OF FINDING AND CATCHING SHRIMP IN COMMERCIAL FISHING

by

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TECHNIQUES OF FINDING AND CATCHING SHRIMP IN COMMERCIAL FISHING

Abstract

The equipment and methods used for finding and catching shrimp are described for some of the world's main shrimp fisheries. Shrimp trawling gear is particularly emphasized and detailed specifications and design drawings of commercially important trawl types are given. The use of echo sounding and other fish finding methods for locating shrimp is described and illustrated with a number of echograms with shrimp traces. An attempt has been made to relate behaviour patterns of various shrimp species to capture.

TECHNIQUES EMPLOYEES PAR LA PECHE COMMERCIALE POUR LA DETECTION ET LA CAPTURE DE CREVETTES

Résumé

Description du matériel et des méthodes utilisés pour la localisation et la capture des crevettes dans certaines des principales pêcheries du globe. L'auteur s'attache particulièrement aux chaluts à crevettes, fournissant les caractéristiques détaillées et les plans de modèles en usage dans les pêches commerciales. Il décrit diverses méthodes de détection employées, notamment le sondage aux ultrasons, et reproduit plusiers échogrammes où figurent des tracés de crevettes. Enfin, il s'efforce d'établir un rapport entre les comportements de diverses espèces de crevettes et leur capture.

TECNICAS PARA LOCALIZAR Y CAPTURAR CAMARONES EN LA PESCA COMERCIAL

Extracto

Se describen el equipo y los métodos empleados para localizar y capturar camarones en alguinas de las principales pesquerías camaroneras del mundo. Se dedica attención especialmente a los artes de pesca al arrastre de camarones, ofreciéndose descripciones detalladas y dibujos del diseño de los tipos de artes arrastreros comercialmente importantes. Se describe el empleo del sondeo por eco y otros métodos para localizar camarones y se ilustra este procedimiento mediante algunos ecogramas con señales de camarones. Se intenta relacionar las formas de comportamiento a la captura de las distintas especies de camarones.

1 INTRODUCTION

In the past the approach to finding and catching shrimp has been largely empirical, and shrimping has been intuitive fishing. Here intuition means a 'knowledge' or 'feeling' born of innumerable past observations, most of which were too vague to be explainable alone but which with time add up to a 'conviction'. However, in the last couple of decades considerable advances have been made towards formulating fishing technology and with time the intuitive approach can be replaced at least partially by technical fishing.

Through the application of engineering methods one can now design trawls to assume the underwater shape one wants and to behave as calculated. However, such 'hybrid' gear does not always bring the hoped for increase in catch rates over traditional nets. The main stumbling block is our very incomplete knowledge and understanding of the behaviour of shrimp (and fish), as well as of other biological and environmental factors. This is, of course, also a major problem in locating shrimp grounds and in finding concentrations of shrimp when fishing.

It is hoped that the documentation and discussions at the present meeting will help to sum up existing knowledge of these factors and to identify gaps in our knowledge towards which research must be directed in the future.

One objective of this paper is to serve as a background to the discussion on shrimp in relation to its environment and availability for capture. Another objective is to describe in considerable detail the gear and mode of operation employed in the major commercial shrimp fisheries, in the hope that this may be of help to beginners in shrimping and possibly of interest to old-timers who are curious to know the equipment and methods of others.

2 SHRIMP FINDING

Before discussing the present techniques of finding shrimp in commercial fisheries, it may be useful to list here the main factors which one knows or suspects may affect the presence and availability of shrimp (Table I).

It is clearly beyond the scope of this paper to attempt to deal separately with all the factors listed in the table except to indicate to what extent they are now taken into account in exploratory and/or day-to-day fishing, and whether they could yield further clues, especially if they were better understood. Many of them are touched upon in the following chapters describing commercial shrimping operations but at this stage a selected few may warrant a separate examination here.

2.1 Environmental factors

When exploring for shrimp in virgin areas, the geographic factors (the first four listed in Table I) often provide the first clue. Among the oceanographic factors, perhaps temperature and turbidity provide the most commonly useful clues. Daylight/darkness, moonlight and eventually cloud cover are perhaps those of the meteorological factors which seem to affect catch rates most obviously in the short run and, of course, the climatological/oceanographic conditions in the long run.

Our understanding of the interaction between meteorological and hydrographic factors has reached the level where short term ('hydropsis') and long term (hydroclime) forecasts can be made of environmental changes affecting fishing conditions (Hela and Laevastu, 1962), and these will in due time become more directly helpful to fisheries, when we gain a better understanding of the influence of the environment on fish behaviour and fish abundance. In the meantime the required background data are becoming more readily available, thanks to centralized world weather watch. Already

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TABLE I   Factors which may affect the presence and availability of shrimp

	Used as guide in shrimp ground exploration	Used as guide in day-to-day commercial fishing	Could give more guidance if observed or better understood	How?
Environmental factors				
Rivers, run-off from the land	Yes		Yes	Better understanding of effect of environmental conditions on shrimp stocks
Lagoons, bays, fjords undersea valleys	Yes		Yes	-do-
Mud or clay bottom	Yes	Yes	Yes	Through better use of suitable echo sounders
Depth	Yes	Yes	Yes	Through better knowledge of bathymetric distribution
Temperature, including thermocline			?	Through better knowledge of tolerance
Salinity			?	-do-
Oxygen			?	-do-
Turbidity	Yes	Yes	Yes	Through better understanding of effect on movement patterns
Currents and tides		Yes	Yes	-do-
Echo sounding and ranging conditions			Yes	Affects need for tuning acoustic equipment to compensate for change in range and sensitivity
Daylight, darkness	Yes	Yes	Yes	Through better understanding of effect on movement patterns
Moonlight	Yes	Yes	Yes	-do-
Cloud cover	Yes	Yes	Yes	-do-
Rain, short term effect on turbidity and light level in inshore waters due to run-off		Yes	Yes	Through better understanding of effect on vertical movement
Wind		Yes	Yes	-do-
Seasonal aspects	Yes	Yes	Yes	Affects choice of fishing grounds and rigging of gear
Weather affecting oceanographic (fishing) conditions, short term : ('hydropsis')		Yes	Yes	-do-

TABLE I (continued)

	Used as guide in shrimp ground exploration	Used as guide in day-to-day commercial fishing	Could give more guidance if observed or better understood	How?
Climatological changes affecting oceanographic (fishing) conditions, long term : (hydroclime)	Yes	Yes	Yes	Affects choice of fishing grounds and rigging of gear
Biological factors				
Species	Yes	Yes		
Age and sexual cycle (phase)	Yes	Yes	Yes	Through better knowledge of migration and behaviour patterns
Seasonal migration		Yes	Yes	-do-
Food supply			?	Short term prediction of occurrence
Range of sensory capacities; response to stimuli			Yes	Through better fishing tactics based on better knowledge of these factors
Swimming speed and endurance, as affecting ability to evade the gear			Yes	-do-
Schooling behaviour: demersal - pelagic		Yes (in Japan)	Yes	-do-
Presence or absence of predators			?	Might affect shrimp behaviour?
Technological factors				
Boats, range, power				
Gear - capable of catching shrimp under various fishing conditions, including in midwater		Yes (mainly in Japan so far)	Yes	Through greater versatility
Fish finding equipment	Yes	Yes	Yes	Through better acoustic equipment and better training in its use
Communications and navigational equipment (R-T; D-F; Loran; Decca)	Yes	Yes	Yes	Through use of more and better equipment and better training
Human factors				
Training and experience are the ones particularly pertinent to the subject under discussion here		*	Yes	* Vocational training in the techniques of finding and catching shrimp and fish is lacking in most countries

now computer centrals receive daily thousands of data of weather and sea conditions, both from land and sea-based observation posts, as well as from satellites. In a matter of minutes the computers can transmit by telex or facsimile (charts) the following products:-

(i) synoptic analysis of weather and sea conditions (by regions and by local areas);

(ii) forecasts of short, medium (3-6 days) and long range of weather and sea conditions, including sea temperature, depth of thermocline, surface currents;

(iii) anomaly computations (e.g., local anomalies, anomalies from longterm mean, etc.), and forecasts of anomalies.

In some parts of the world the shrimp fishing industry could already make far better use of such services (i) and (ii) as guidance in day-to-day operations, and (iii) for longer range planning. The latter can, for instance, give a valuable clue as to the likely effect of drought or periods of heavy rain on shrimp abundance in nearby coastal waters months later. An example of this is the great slump in Indian shrimp production due to the severe drought caused by failure of the southwest monsoon rains in 1965.

2.2 Biological factors - behaviour

Among the biological factors, the one which is perhaps the most variable and most affected by changes in the environmental conditions is the schooling behaviour, demersal-pelagic state. As a result of better fish finding equipment, midwater trawls and other pelagic fishing methods, one steadily gains better knowledge of the pelagic behaviour of shrimp. However, it goes without saying that much remains to be learned about this. The same can be said about other species of fish. Species which have been classified as demersal, and have traditionally been caught mainly on the bottom, are now known to be pelagic in a certain phase or under certain environmental conditions, and are now being caught with essentially pelagic fishing methods. Thus cod, for instance, is now caught in purse seines. The converse is also true; herring and sardine are increasingly caught in bottom trawls. Consequently, the terms demersal and pelagic are more descriptions of behaviour at a given time than general classifications of species. In this context, shrimp is more pelagic than was generally realized before. Perhaps we could say that shrimp is as pelagic as it needs to be to forage, and as it dares to be from the point of view of visibility to predators, as affected by water turbidity and light intensity.

The major problems in studying the behaviour of shrimp are caused by low visibility in its habitat, and the difficulty of receiving acoustic signals from it due to its small size and the absence of a swim bladder.

About a decade ago, shrimp fishing in the Gulf of California failed suddenly for a couple of years. At the time there was much speculation as to the causes: Overfishing? Sudden decline in stock strength due to natural causes? Some people in the industry wondered whether the shrimp was still there but staying in midwater, due to changed oceanographic conditions, and therefore unavailable to capture in bottom trawls? FAO received a request from Mexico for technical assistance in investigating the last-mentioned hypothesis, by means of diver observation or underwater TV and midwater trawling. Direct or TV underwater observation had to be ruled out on the grounds of low visibility in the turbid waters on the shrimping grounds, and midwater trawling was then still in an early experimental stage. At any rate, blind midwater trawling, without knowing the depth of the schools, is fairly hopeless. Enquiries brought to light that shrimp schools had not been detected in midwater by echo sounding in these areas. Consequently no action could be taken purposefully at that time along the lines proposed by those who believed that the shrimp was in midwater and could be caught there if we had the right tools and techniques. Fortunately the shrimp returned to its former habits and bottom trawling became productive again.

But what would the situation be today if we were again faced with such a problem? Midwater trawling gear and techniques have now been developed to the stage where the net can be aimed at the right depth to intercept the schools, if the shrimp can be detected acoustically. Such gear and techniques are described in a following chapter on Japan. The solution to the problem would seem to hinge on the effectiveness of echo sounding.

2.3 Technological factors - echo sounding

It is hardly a controversial statement to say that echo sounding is generally of great help in locating a mud or soft clay bottom. However, detecting shrimp is another and more difficult problem. Apart from their small size, shrimp are basically poor echo sounding targets because of the absence of an air bladder, which in fish accounts for much of the target strength. In theory high frequency sounding should be more effective than the medium frequencies commonly used in most fisheries (outside Japan) for detecting small targets like shrimp, because of the shorter wave length. The formula $\lambda = \frac{c}{f}$ relates the wavelength (λ) speed (c) and frequency (f) of sound:

50 kc/s therefore corresponds to a wavelength of $\frac{1500 \times 100}{50 \times 1000} = 30$ mm and

200 kc/s corresponds to a wavelength of $\frac{1500 \times 100}{200 \times 1000} = 7.5$ mm

The wave length of 7.5 mm should be particularly suitable for the detection of such small targets. However, reasonably dense shrimp schools, and possibly big size shrimp, can under certain circumstances be detected clearly with medium frequency (38.5 to 50 kc/s) echo sounders - properly used - as illustrated in Figs. 1, 2 and 3.

High frequency echo sounders are not yet in general use outside Japan, but there they are commonly used in the shrimp fisheries (and also for other fishing). Many of the boats are equipped with both high frequency, 100 to 200 kc/s, and medium frequency, 20 to 50 kc/s, or dual frequency sounders of high power. Having two frequencies helps to correctly interpret the traces observed since the medium frequency sounders are less sensitive to small organisms, and also give better bottom penetration. Some of the Japanese shrimp fisheries rely heavily on echo detection of the shrimp since the depth of the trawl must be adjusted to intercept the shrimp schools off the bottom or in midwater. This applies particularly to midwater trawling for Penaeus orientalis in the Yellow Sea and East China Sea.

The echograms in Figs. 4, 5 and 6 are all recorded on moist paper with 200 kc/s echo sounders of medium size and power. Most of these shrimp schools are recorded in depths of 35 to 85 m (19 to 46 fm). A further echogram showing dense schools of shrimp (Penaeus orientalis) in the Yellow Sea is shown in Fig. 45.

Fig. 6 shows clearly the settling of shrimp schools towards the bottom at dawn between 0630 and 0730 hours in February at Hokkaido.

These echograms of shrimp schools may surprise some people in commercial shrimping or research. It is useful to realise to what extent shrimp can be detected with present day acoustic equipment. It is also necessary to realise the great need for further development in this field. Even with the present state of knowledge of acoustics and electronics, it should be possible to produce specialized equipment with greater capability for detecting shrimp under less than ideal conditions. Bearing in mind that shrimping is already a very big business and is rapidly becoming a bigger one, it would seem to be worthwhile for echo sounder manufacturers to cater for this market.

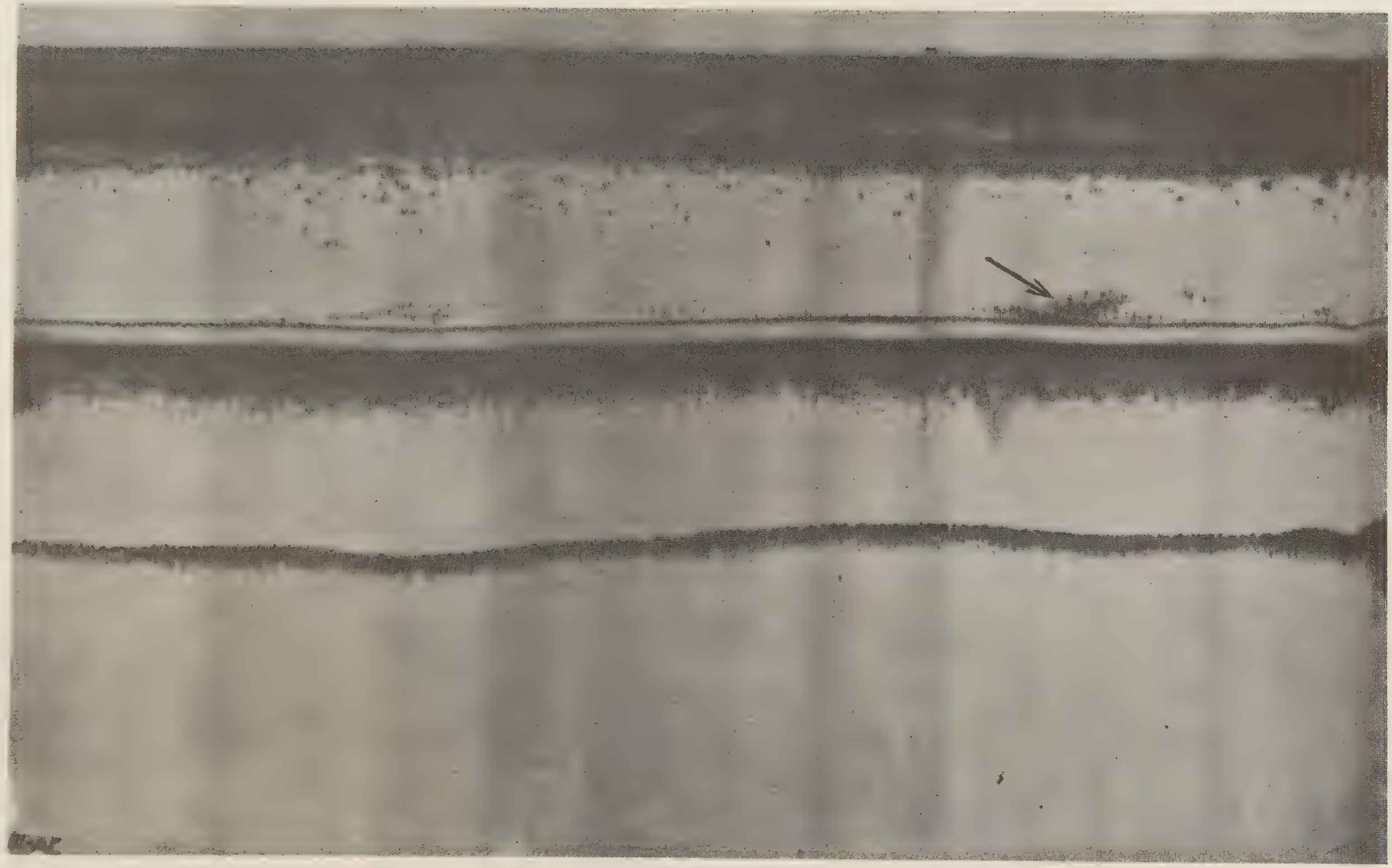


Fig. 1 Shrimp school (*Pandalus borealis*) at the bottom in 90 fm (165 m), sounder range 0 - 260 fm (0-475 m) in Skagerak, near Hvaler, Norway. The catch was 200 lb (91 kg) of large shrimp.

Echo sounder: SIMRAD Mod EH2C
Frequency: 38.5 kc/s
Pulse length 5 millisec

Paper speed: 5 mm/min
Sensitivity: 5
Moist paper

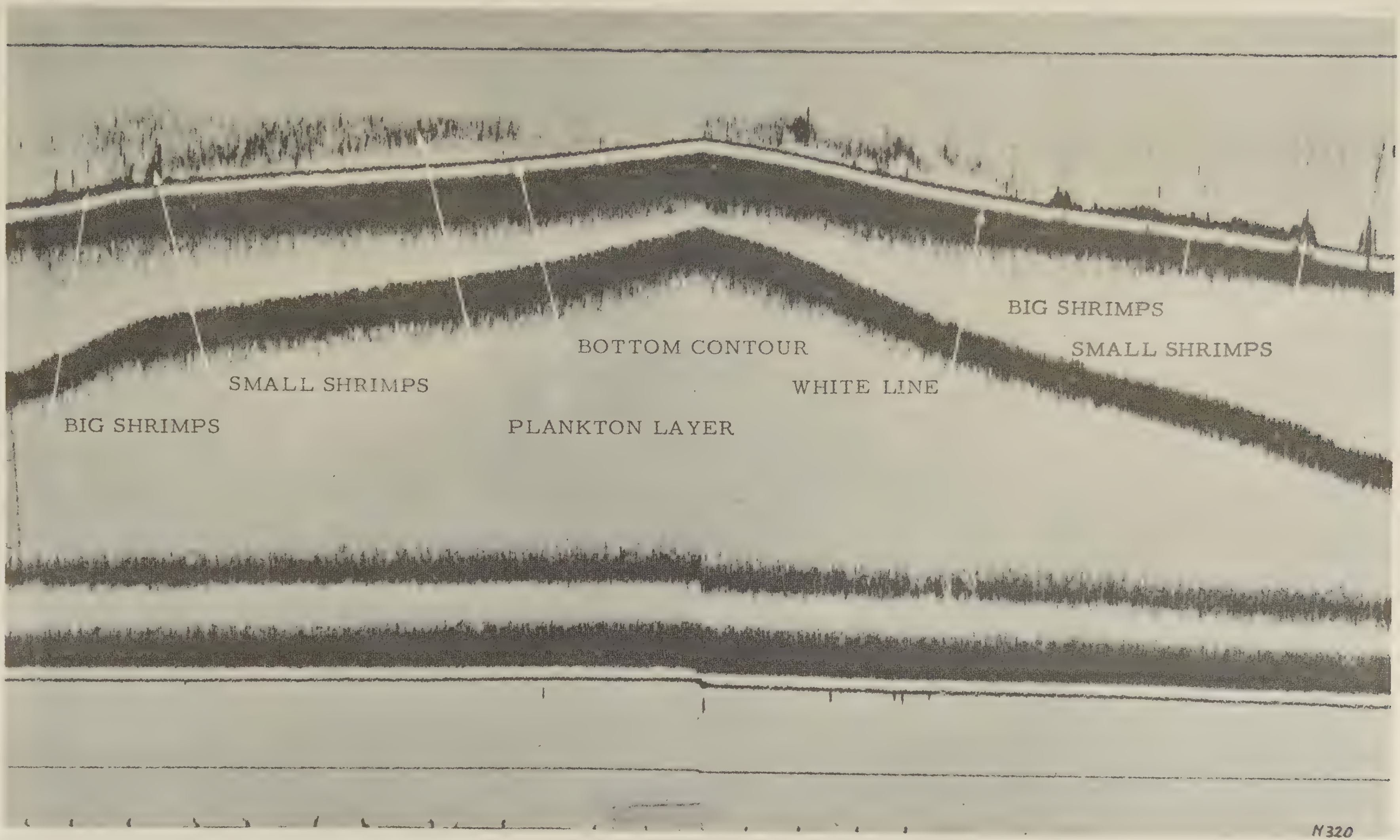


Fig. 2 Schools of shrimp, probably Penaeus indicus, detected at the bottom in a depth of 6 to 10 fm (10–18 m) with a SIMRAD echo sounder Model 512-15 WL (white line) in the Persian Gulf, **October**, 1963.

Scale: 0 – 40 fm (0–73 m)
Frequency: 38.5 kc/s
Pulse length: 1 millisec
Rate of soundings: 180 min

Paper speed: 7 mm (1/4 in) per min
Dry paper
Note that the echogram paper has been used twice

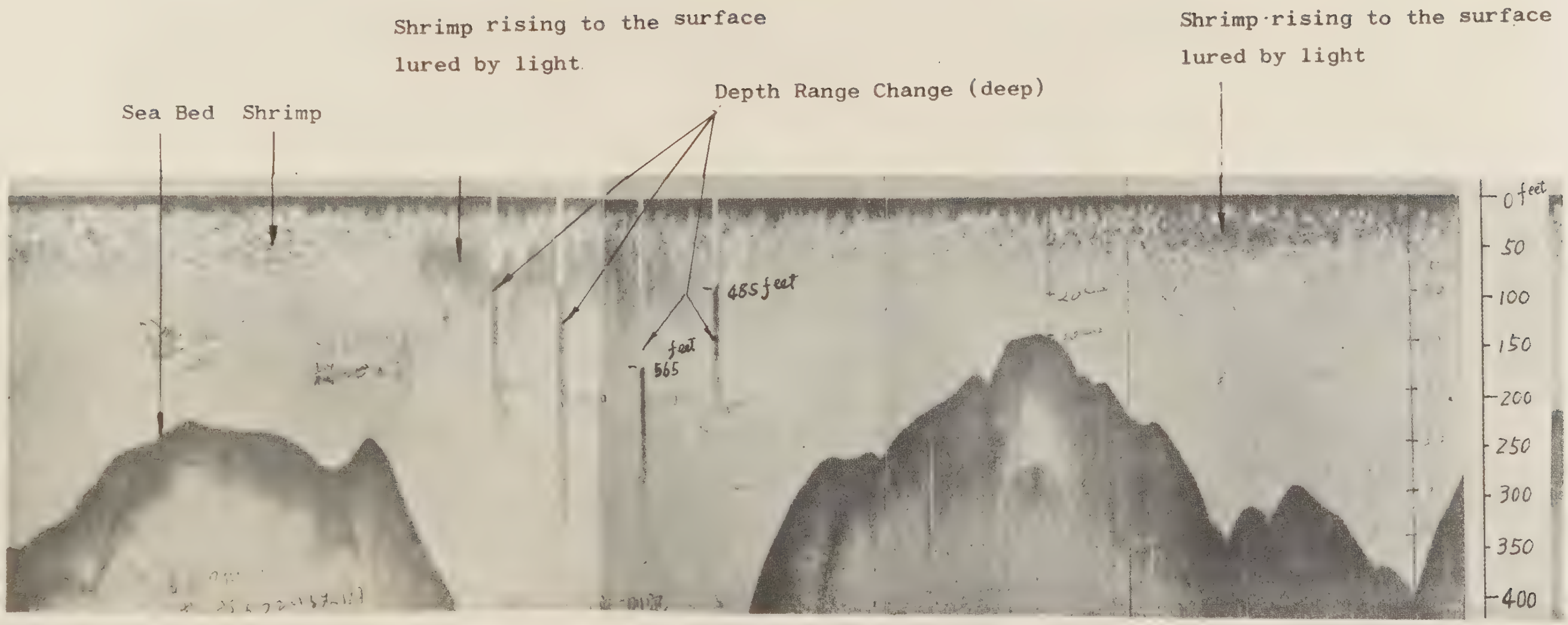


Fig. 3 Sergestes lucens rising to the surface lured by white incandescent light at night, February 1960, near Yaizu, Shizuoka Prefecture, Japan. Recorded on echo sounder model NJA-150 (NMD-231), 50 kc/s with side board mounted transducer on 5 ton wooden boat.

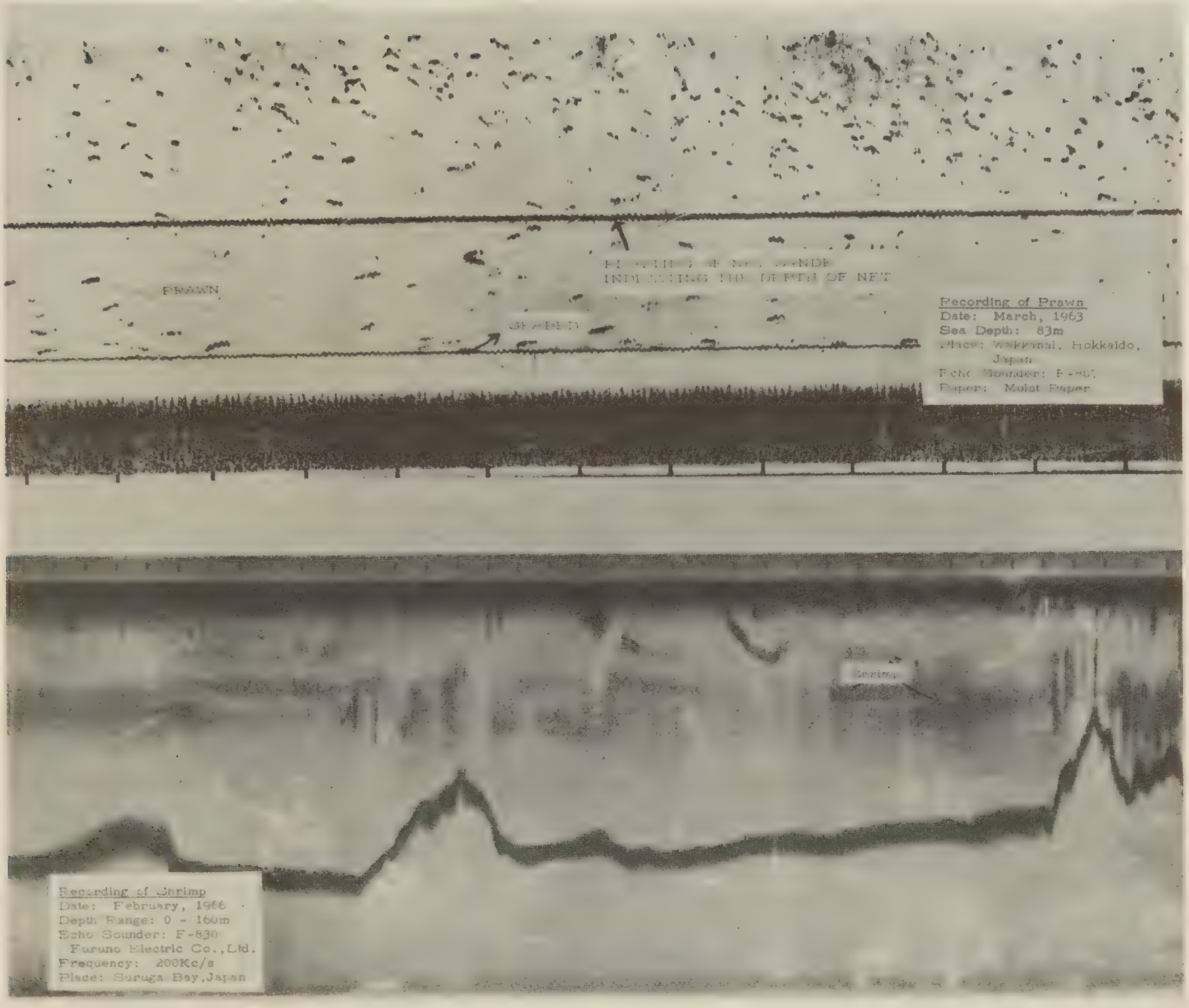


Fig. 4 Upper echogram shows recording of shrimp, Pandalus kessleri or P. borealis, at Wakkanai, Hokkaido in March 1963. Sea depth 83 m, recorded on echo sounder F-807, with white line which helps to distinguish shrimp echoes near the seabed. The dark line through the middle of the echogram shows the headline height of a trawl recorded by netsonde.

Lower echogram shows shrimp schools in midwater in Suruga Bay, Japan in February 1966. Depth range 160 m, depth of shrimp schools approximately 50 to 60 m, recorded on echo sounder F-803, 200 kc/s, moist paper.

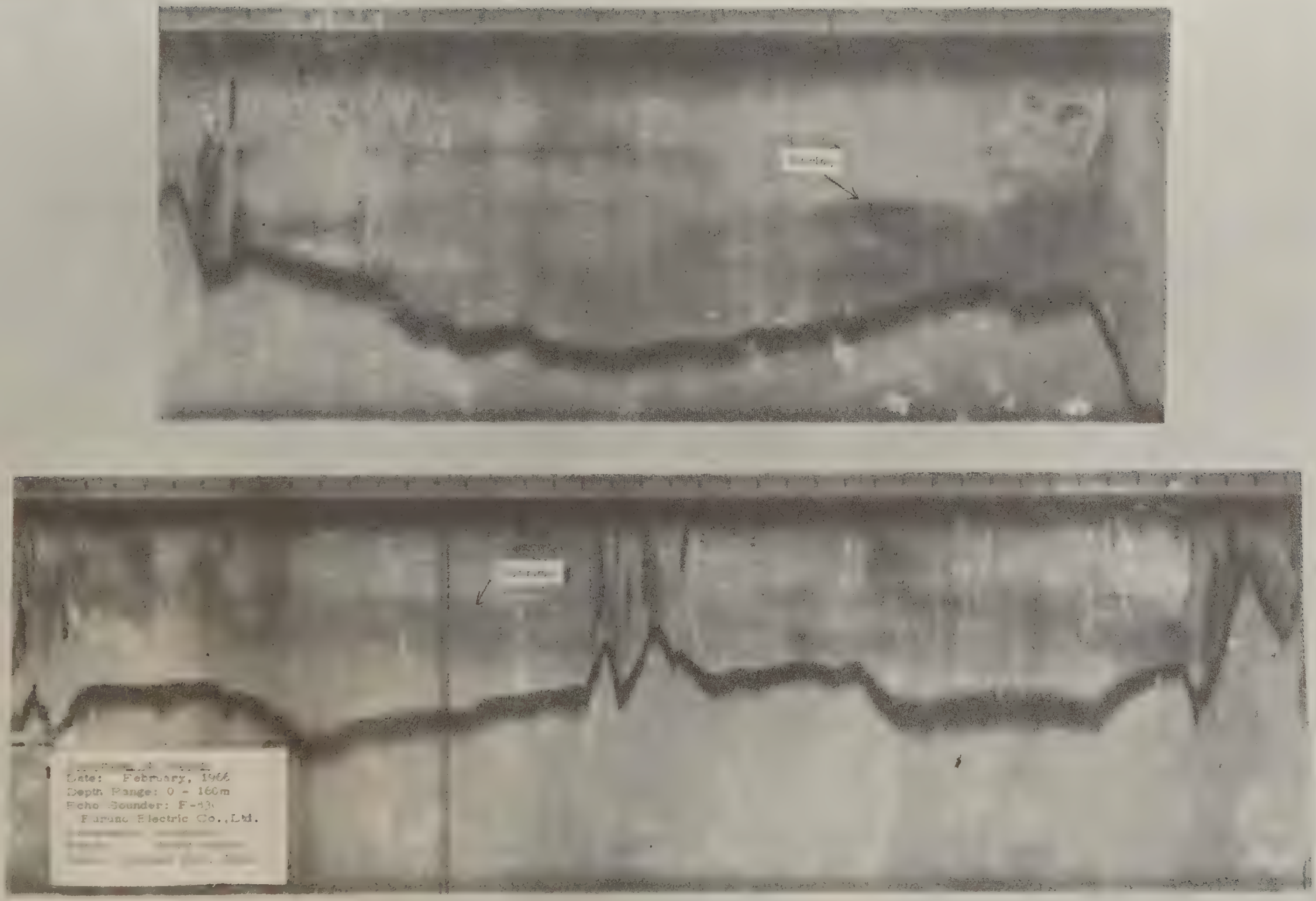


Fig. 5 Shrimp schools, Sergestes lucens, in midwater in Suruga Bay, Japan, February 1966, recorded on echo sounder F-830, 200 kc/s, moist paper, depth range 0-250 m.

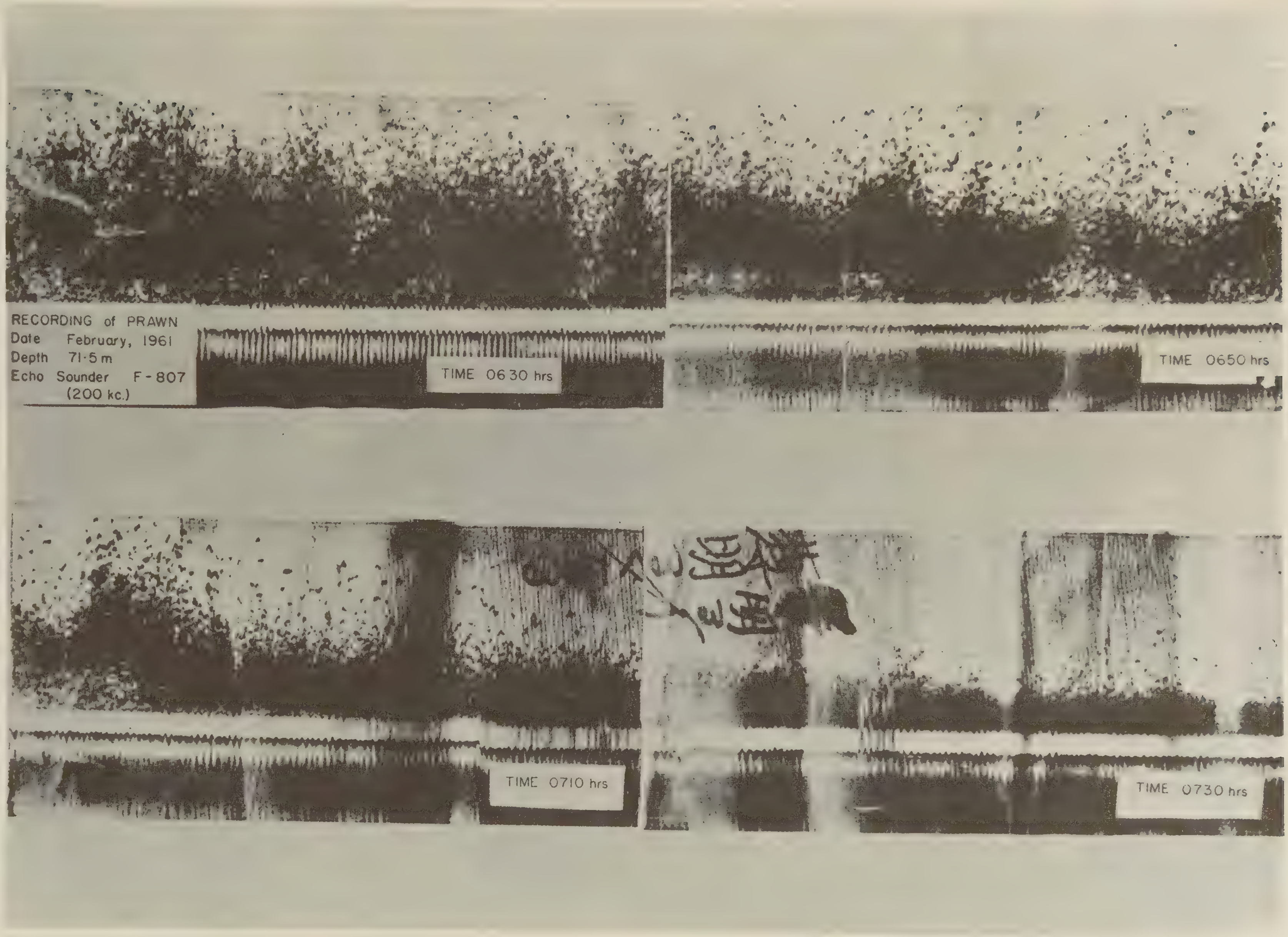


Fig. 6 Shrimp (Pandalus kessleri) settling towards the bottom at dawn between 06.30 h (upper left hand corner) to 07.30 h (lower right hand corner) recorded on Furuno echo sounder F-807, 200 kc/s, moist paper, in February 1961 at Wakkanai, Hokkaido, Japan.

2.4 Human factor

No matter how good fish finding equipment is, its usefulness still depends on the operator. Perhaps one can say that the echo sounder is like a blind man's seeing-eye dog. The user needs training with the tool to get good results.

Fish finding equipment is offered in the market in a great variety of different models with different characteristics, and it is a highly complex matter to select the unit best suited to the fishing conditions under which it is to be used. As the equipment becomes more sophisticated the models acquire more control knobs. These need to be correctly adjusted for proper tuning of the equipment and for proper functioning under each given set of circumstances. It might be technically feasible to build fully automatic units with no controls apart from an on/off switch, but this will surely be uneconomic in the foreseeable future. In the meantime the fishermen must learn how to cope with the complexities.

Capitalization and use of complex equipment for finding and catching fish calls for organized training of fishermen, as for other trades and professions. It is simply not economic any longer to learn exclusively on-the-job by trial and error. Quicker results can be obtained by a suitable combination of on-the-job training and teaching on shore, where better explanation can be given by printed texts, visual aids, fishing simulator and other means of organized training. It is plainly too expensive to use vessels costing tens of thousands of dollars for skippers to learn by their own mistakes how to utilize modern equipment effectively - and perhaps never learning it well enough. Training should pay-off in proper selection of gear and its rigging, selection of suitable fish finding equipment and effective use of it, and a keen understanding of costs and earnings, of ultimate profit to fisherman and vessel owner.

3 SOME IMPORTANT SHRIMP FISHERIES

The techniques and equipment used for finding and catching shrimp in a few of the world's shrimp fisheries will be described below. The Gulf of Mexico shrimping is described in rather greater detail than the other fisheries, not only because it is the world's biggest in terms of production, but because the gear and methods used there have also found application elsewhere.

3.1 Gulf of Mexico

Annual production from this area (including the southeast U.S.A.) during 1965 was approximately 120,000 t - 19 percent of the world's total. Of this, about 100,000 t were landed in the U.S.A. and 20,000 in Mexico (this excludes the 40,000 t landed on Mexico's Pacific coast).

3.1.1 Grounds and species fished Three species of shrimp constitute practically the entire commercial catch in this area; pink shrimp (*Penaeus duorarum*), brown shrimp (*Penaeus aztecus*), ahd white shrimp (*Penaeus setiferus*). In addition. lesser quantities of royal red shrimp (*Hymenopenaeus robustus*) and sea-bobs (*Xiphopenaeus kroyeri*) are taken.

The pink shrimp is taken off Florida's east coast, in the east Gulf from Pensacola, Florida, south along the Florida coast, and on the Campeche Bank to Ciudad del Carmen, Mexico. The type of bottom in these areas is characterized by sand, shell and coral gravel, and by live coral overlying white, calcareous mud (Springer and Bullis, 1954). Within these areas there are extensive grounds with coral, rock and loggerhead sponges which make trawling with standard gear impossible. The normal fishing depths for this species range from 5 to 35 fm (9 to 64 m). An active fishery exists the year round but is definitely seasonal with regard to effort and catches.

In the northeast Gulf the best fishing season extends from early spring to late autumn. On the Tortugas (off south Florida) and Campeche grounds peak production is during the winter months.

The brown and white shrimp fisheries are off Georgia and Florida's east coast, and from northeast Florida west and south to Ciudad del Carmen, Mexico. The bottom types consist primarily of terrigenous mud with sand out to about 30 fm (55 m). Mud lumps and large coral-rock structures are common beyond the 50 fm (91 m) curve, out to the edge of the shelf (Springer and Bullis, 1954).

The depth range of the brown shrimp fishery is out to 50 fm, whereas the white shrimp are taken within the 20 fm (37 m) curve. Both brown and white shrimp fisheries are seasonal, particularly the whites. These are taken almost entirely during the late autumn and winter. The brown are fished the year round with major production occurring in the late summer and autumn.

Royal red shrimp production is still very small and is taken almost entirely from one area off Florida's east coast, although the species is found throughout most of the Gulf of Mexico in the 175 to 250 fm (320 to 457 m) depth range. In addition to these grounds, the U.S. Bureau of Commercial Fisheries has also located potential commercial concentrations off Dry Tortugas, Florida and off the mouth of the Mississippi River (Bullis, 1956). Large scale utilization of these resources is probably contingent upon introduction of gear better suited for operation in these much deeper waters.

3.1.2 Vessels The vessels, gear, and methods of operation have changed drastically over the years, due primarily to increasing availability of reliable power units and the need to operate on deeper and/or more distant grounds. The early shrimp trawlers were open skiffs 15 to 25 ft (5 to 8 m) long, powered with gasoline engines. By the twenties they were decked over, the engine placed forward, and a pilothouse added forward. This arrangement remains the standard for today's shrimp trawlers. In the thirties the diesel engine was introduced and average size increased somewhat. During the forties and fifties the need for larger vessels to exploit offshore grounds resulted in construction of much larger vessels. Average vessel length increased to about 60 ft (18 m) with many in the 70 to 90 ft (21 to 27 m) range (Captiva, 1967). Of particular interest during this period was the success of production line model shrimp vessels (Fig. 7), built to standard specifications with design emphasis on minimum cost. They were 67 ft (20 m) hulls powered with 150 to 200 hp engines and characterized by a very high freeboard. This together with the ample sheer fore and aft provided a very dry working deck (Ringhaver, 1960). During the sixties the trend has been towards larger, better equipped and more powerful vessels, capable of long distance operations. Most vessels are well fitted with electronic equipment. These include radio-telephones, automatic pilots, echo sounders, and frequently loran receivers and radio direction finders. A trend in recent years has been to increasing use of citizens band transceivers for short range communication (up to 60 mi or 100 km).

3.1.3 Double-rig otter trawling The first attempts to develop the double-rig method in the Gulf of Mexico were made by shrimp fishermen at Rockport, Texas, late in 1955 (Knake *et al.*, 1958). Since then the technique has been virtually universally adopted by fishermen in the southeastern United States and Mexico. It has also been adopted as the standard method by fishermen in recently exploited areas such as Central America, the northeast coast of South America, the Persian Gulf and Nigeria.

The rapid acceptance of double rigging by the American fishermen stemmed from recognition of a number of advantages inherent in the method. The most significant of these is the claim of increased catches per vessel. While only estimates of increased catches can be made, many vessel operators believe a 15 to 30 percent increase is realized (Knake *et al.*, 1958). The reasons advanced for the superiority of the method are that two small nets sweep a wider path (have greater horizontal spread) than one

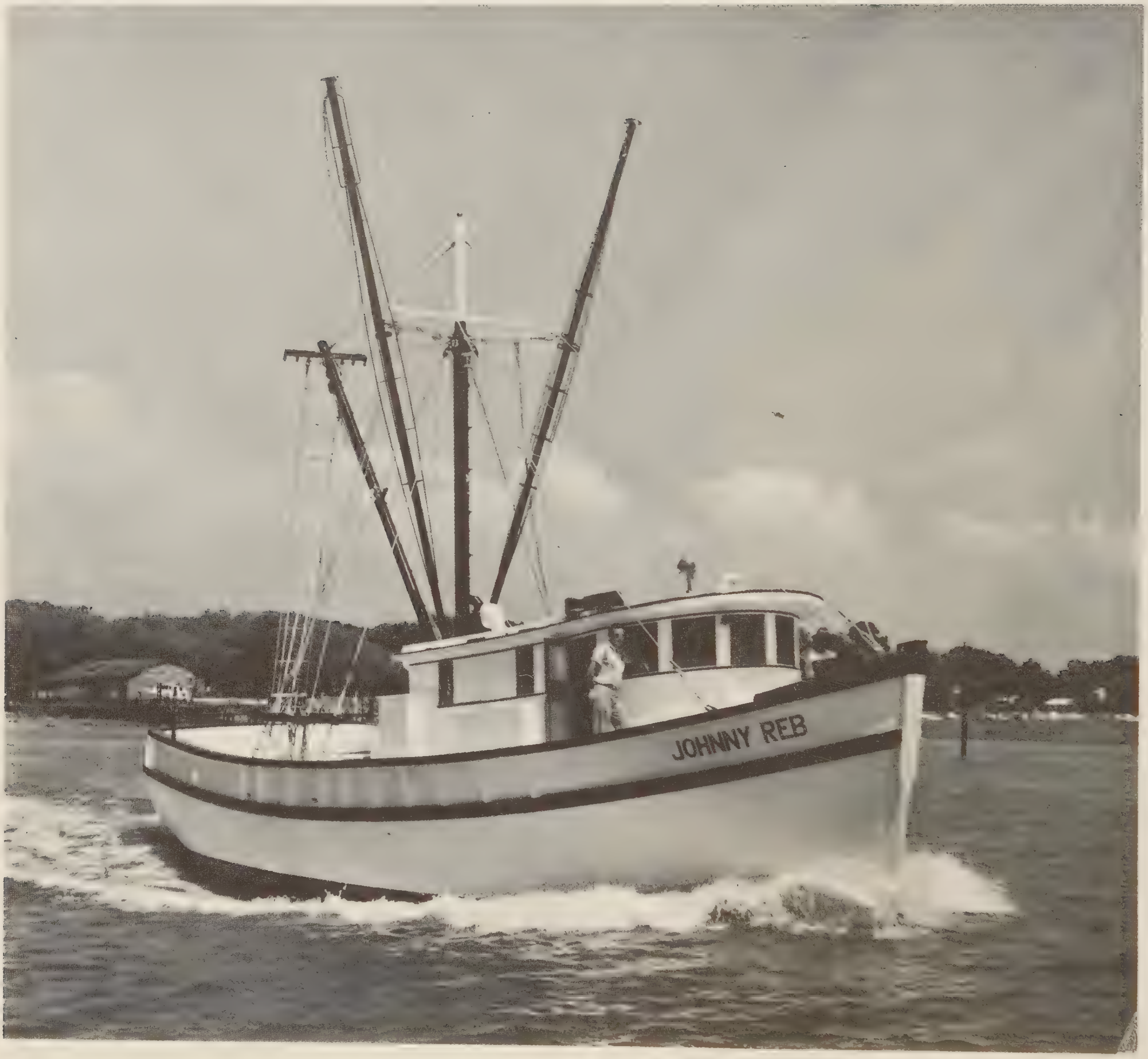


Fig. 7 A 67-ft double-rigged shrimp trawler (courtesy of Diesel Engine Sales Co. Inc., St. Augustine, Florida).

big net of equal towing resistance, and also fish more efficiently on an uneven bottom.

Another advantage claimed for the double-rig is that losses of time, labour, and money spent on gear are lessened. This is because, in many instances, only one small trawl need be repaired or replaced rather than a large one. Also, vessel crews favour the double-rig because they benefit financially from larger catches and because less effort is required to operate the gear than with the much larger single trawl.

The basic double-rig system (Figs. 8 and 9) consists of two outrigger booms mounted usually on the port and starboard side of the mast 5 to 7 ft (1.5 to 2 m) above the deck. The outriggers are stayed fore and aft as well as vertically. The length of outriggers ranges from 24 to 40 ft (7 to 12 m) on the larger vessels, and are rigged to operate at an angle of 20 to 30 degrees from the horizontal. In addition to serving as towing points for the trawls they are used to suspend stabilizer planes. The stabilizers are normally suspended from the ends of the booms and operate 15 to 20 ft (4.5 to 6 m) below the surface of the water. The purpose is to dampen the roll of the vessel. They are particularly effective when the vessel is anchored in rough water.

A typical double-rigged vessel of 60 to 70 ft (18 to 23 m) operates with a crew of three. This may be increased to four or reduced to two depending on the workload involved. Such a small crew for a fishing unit is possible because of the relatively low volume production of a valuable species, a minimum of product handling, and simplicity of vessel equipment.

3.1.4 Trawl gear The only shrimp fishing gear of significance in this are is the otter trawl. The first commercial shrimp trawls were introduced sometime between 1912 and 1915 off Florida's east coast. These were patterned after the otte trawls then being used by the U.S. Bureau of Fisheries at Beaufort, North Carolina (Anderson, 1958). They were rapidly adopted and by 1917 had displaced the traditional haul seine as the standard commercial gear (Captiva, 1967).

In the Gulf of Mexico there are two principal trawl designs, with numerous variations of each. These are the flat trawl and the 4-seam semi-balloon. In addition, the 2-seam balloon and western jib designs are used, but not nearly so generally. Sizes of trawls vary from 30 to 90 ft (9 to 27 m) (headline) with the 40 to 60 ft (12 to 18 m) size range most common. Trawl size is designated by the headline length, excluding the leg lines.

Synthetic netting primarily nylon, is used almost exclusively, due to its strength, resistance to deterioration and relatively low cost. After assembly, nets are tarred to reduce wear due to abrasion and as a stiffening agent. This is repeated periodically while in use, usually every six to twelve weeks.

The use of each design is not restricted to specific geographic areas or species as might be expected, but instead all are used on all grounds. It is a common belief that a flat trawl has inherently a wide spread and a low opening height and that the balloon trawl opens high. This is not necessarily so. Although all types could be rigged by the individual fisherman to fish either with a relatively high opening or with a maximum horizontal spread, the latter is normally emphasised. All types are rigged at various times to fish either light or hard on the ground.

Measurements by the U.S. Bureau of Commercial Fisheries of 40 ft (12 m) trawls in operation revealed that the semi-balloon nets had a wider spread (32 ft) (10 m) and a lower headline (4 ft) (1.2 m) than the other two designs. The flat trawl spread to 28 ft (8.5 m) and headline height was about 5 ft (1.5 m). The 2-seam balloon trawl configuration was intermediate to these. The measurements are only approximate since the configurations varied widely under different towing conditions; however, the relationships between the three designs under similar conditions were as described.

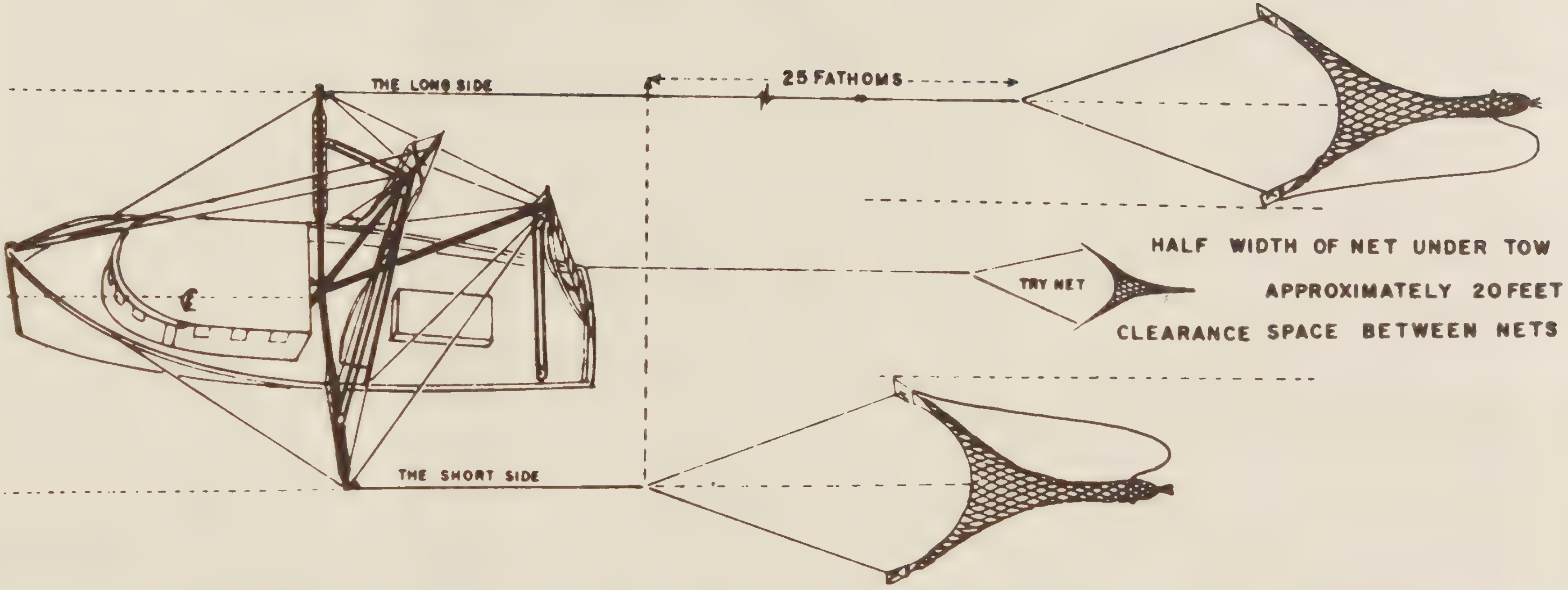


Fig. 8 A diagrammatic representation of double-rig shrimp trawling (Courtesy U.S. Bureau of Commercial Fisheries).

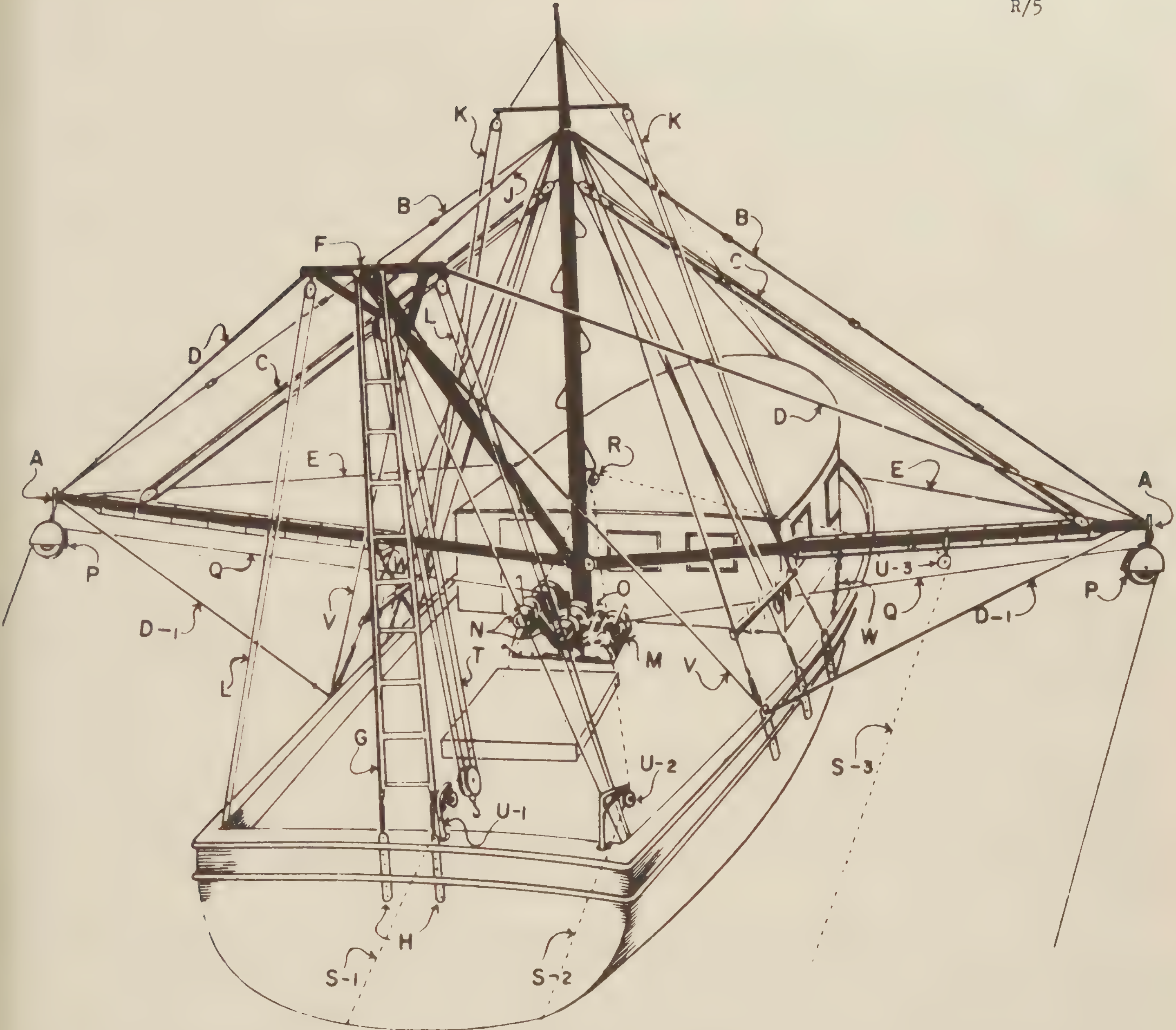


Fig. 9 Rigging arrangements for double-rig Shrimp Trawling

A - towing boom or outrigger; B - towing boom topping stay; C - topping lift tackle; D or D-1 - towing boom outrigger back stay; E - towing boom outrigger bow stay; F - modified boom; G - boom back stays - ratline structure; H - boom back stay plate on transom; J - boom topping lift stay; K - single block tackle; L - single block tackle; M - trawl winch; N - heads, two on trawl winch; O - centre drum for trynet warp; Q - warp; R - leading block for trynet; S-1, S-2, S-3 - trynet lead block; T - main fish tackle tail block; U-1, U-2, U-3 - trynet lead block; any one may be used to accord with selection of S-1, S-2 or S-3; V - boom shrouds; W - chain stoppers for outriggers. (Courtesy of the U.S. Bureau of Commercial Fisheries).

3.1.4.1 Flat trawl Gulf of Mexico trawls have been described by Bullis (1951) and Fuss (1963) and are briefly summarized here. Design drawings with material specifications of flat trawls of 43 ft (13 m) and 66 ft (20 m) headline lengths are shown in Figs. 10 and 11 respectively. Both nets are drawn to the same scale; note the great difference in size. The flat trawl is made from four panels of netting; top, bottom and two sides. The top and bottom panels are each made up of three sections, a large body section and two corner pieces. The corner pieces in the flat trawl are referred to as "jibs". This design differs from the others in the construction of the jibs. Each is fashioned roughly in the shape of 120° - 30° - 30° triangle by cutting two edges on a 1 mesh, 2 bar taper. The long untapered side of the jib is the hanging edge. This method of cutting and assembly results in towing strain running along the bars of the jib meshes rather than in a straight twine direction.

It is standard practice to provide a "set-back" of the bottom panel. The purpose of this is to obtain a cover of netting (overhang) above the footrope to prevent upward escapement of shrimp. The overhang of the net in Fig. 10 is obtained by setting the bottom body section back 10 meshes and by hanging the netting to the headline with more slack than to the footrope. To compensate for the shorter bottom body the bottom jibs are made longer. These features result in a footrope 44 ft 7 in (13.6 m) long and a headline 43 ft (13.1 m) long. In operation the center (bosom) of the footrope of this trawl tows approximately 2 ft (0.6 m) behind the center of the headline.

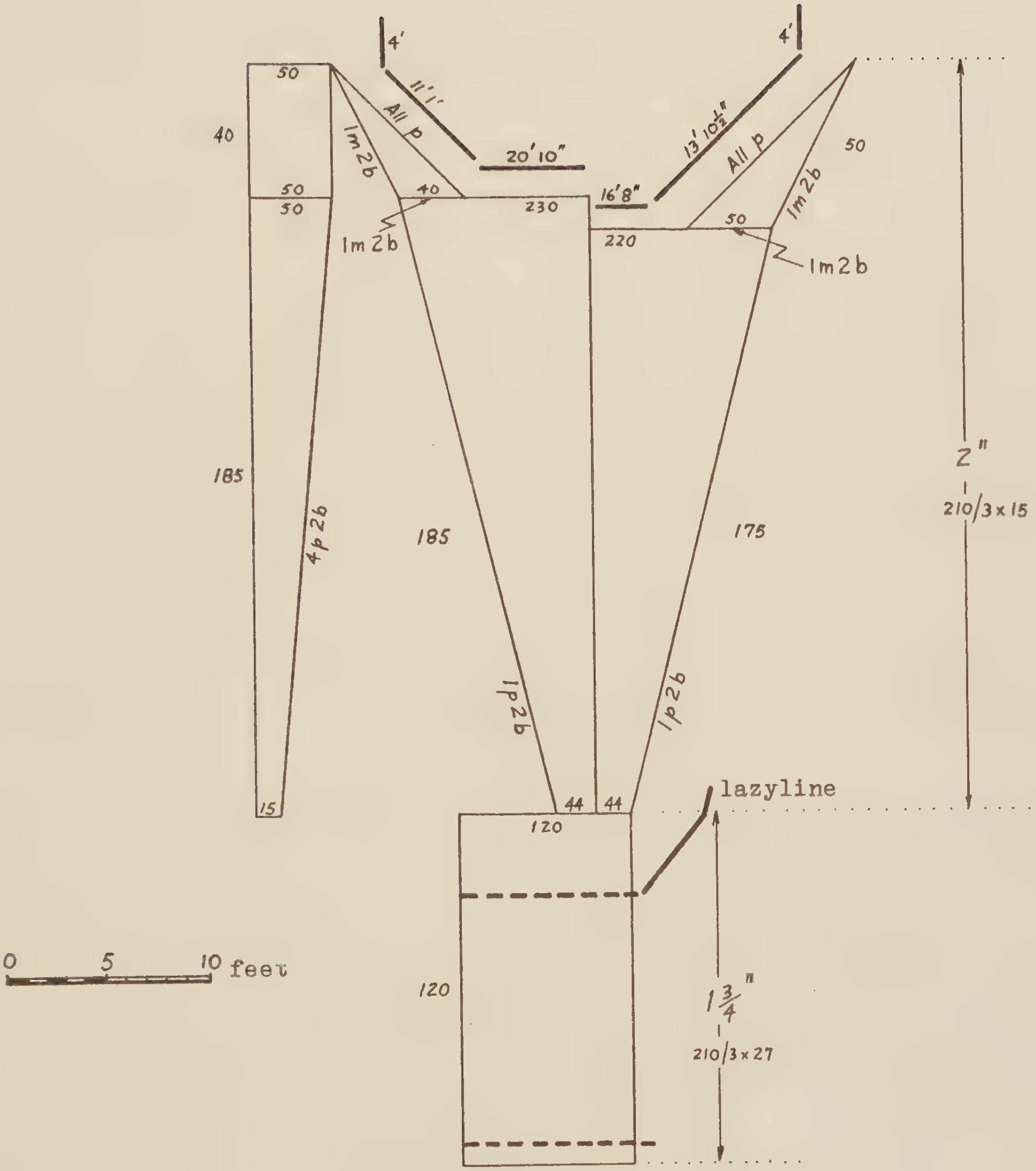
The major modification to this design is the use of untapered side panels. In this case the (top and bottom) body panel tapers are continued back to points so that the total number of meshes around the funnel in front of the codend remain approximately the same as in the standard design. This construction feature is illustrated by the trynet shown in Fig. 12.

3.1.4.2 Semi-balloon trawl The semi-balloon trawl (Fig. 13) is also constructed from four panels similar to those of the flat trawl. The principal difference being the shape of the corner pieces and the much greater set-back. The corner pieces are right isosceles triangles, cut all-bars on the hanging edges (inside edges). It has been found that increasing the taper of the corner piece near the bosom provides a shape which better distributes the towing strain in this high stress zone.

3.1.4.3 Western jib trawl This design is similar to the flat trawl in that it is of 4-seam 4-panel construction. The pertinent feature is the shaping of the corner piece or jib. It is cut as shown in the in-set in Fig. 12. The primary advantages of this are that the netting is stronger in the corners, with the strain distributed in the twine direction rather than along the bars. Consequently less labour and expense is involved in re-hanging and repairs. V.L. Harris and R.C. Rhodes were granted United States patent 2,816,386 for this invention in 1957.

3.1.4.4 Two-seam balloon trawl The two-seam design (Fig. 14) is constructed from two panels which are joined forming a single seam on each side of the trawl. In addition to only two seams, this design is characterized by the way the corner pieces and bodies are shaped. The corner pieces are cut all-bars along the hanging edge and all points along the forward and back edges. The outer edge has the same taper as the body. To compensate for the absence of side panels, the top and particularly the bottom panels are much wider than for a similar size trawl of other designs.

3.1.4.5 Accessory gear To obtain satisfactory bottom tending performance the trawl footrope is weighted with chain. The size used is usually ¼ in (6 mm) diameter on smaller trawls, ranging up to 3/8 in (10 mm) on larger ones. It is secured directly to the footrope in loops (Fig. 15). The loop sizes are variable



Headline: 43 ft (43 + 4 + 4) - 3/8 in. comb. rope

Footrope: 44 ft 7 in. (44ft 7 in. + 4 + 4) - 3/8 in. comb. rope

Fig. 10 Gulf of Mexico 43 ft Flat Trawl.

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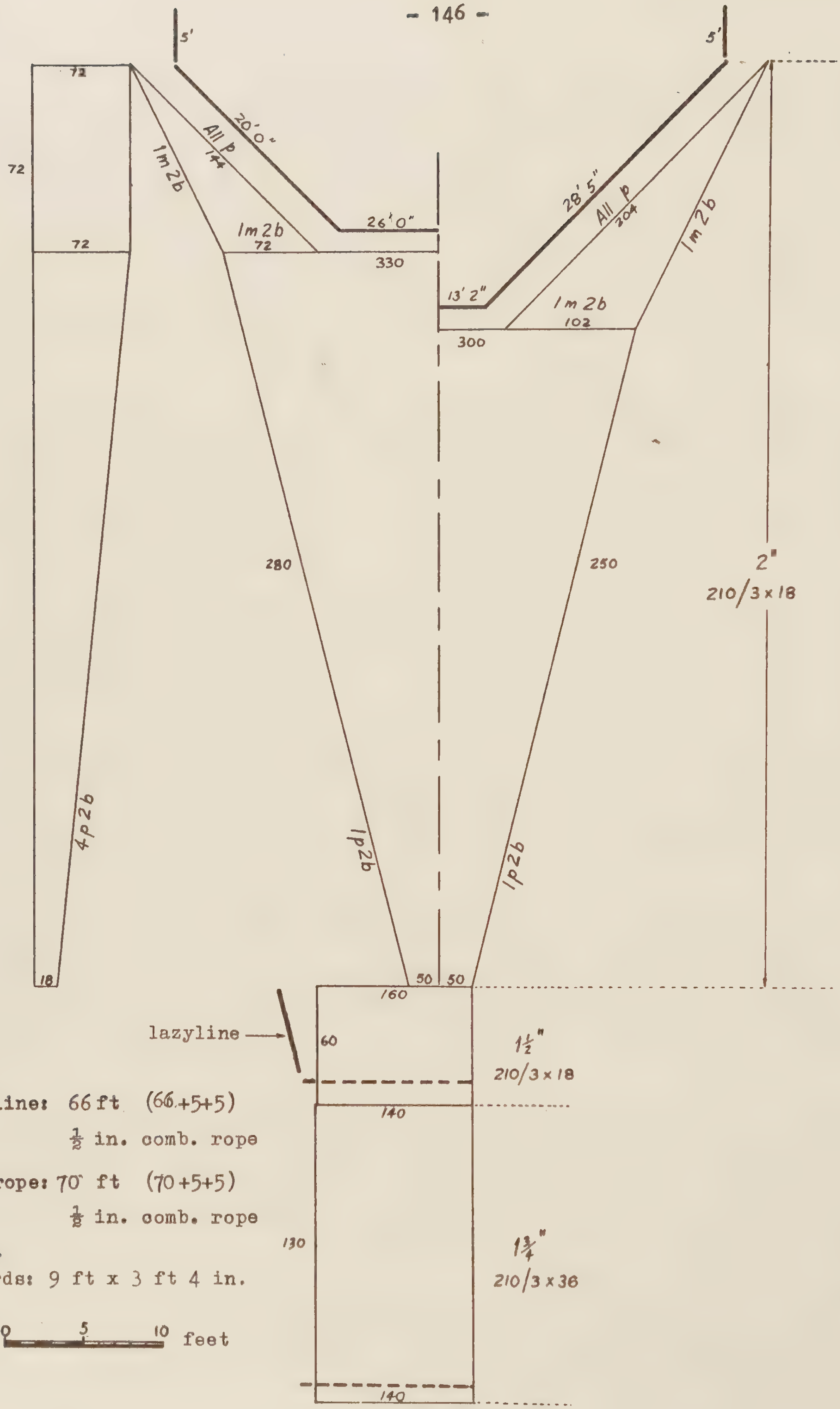

Headline: 66 ft (66+5+5)
½ in. comb. rope

Footrope: 70 ft (70+5+5)
½ in. comb. rope

Otter boards: 9 ft x 3 ft 4 in.

Fig. 11 Gulf of Mexico 66 ft flat trawl.

Headline and Footrope : 15½ ft. - 3/8" polydacron

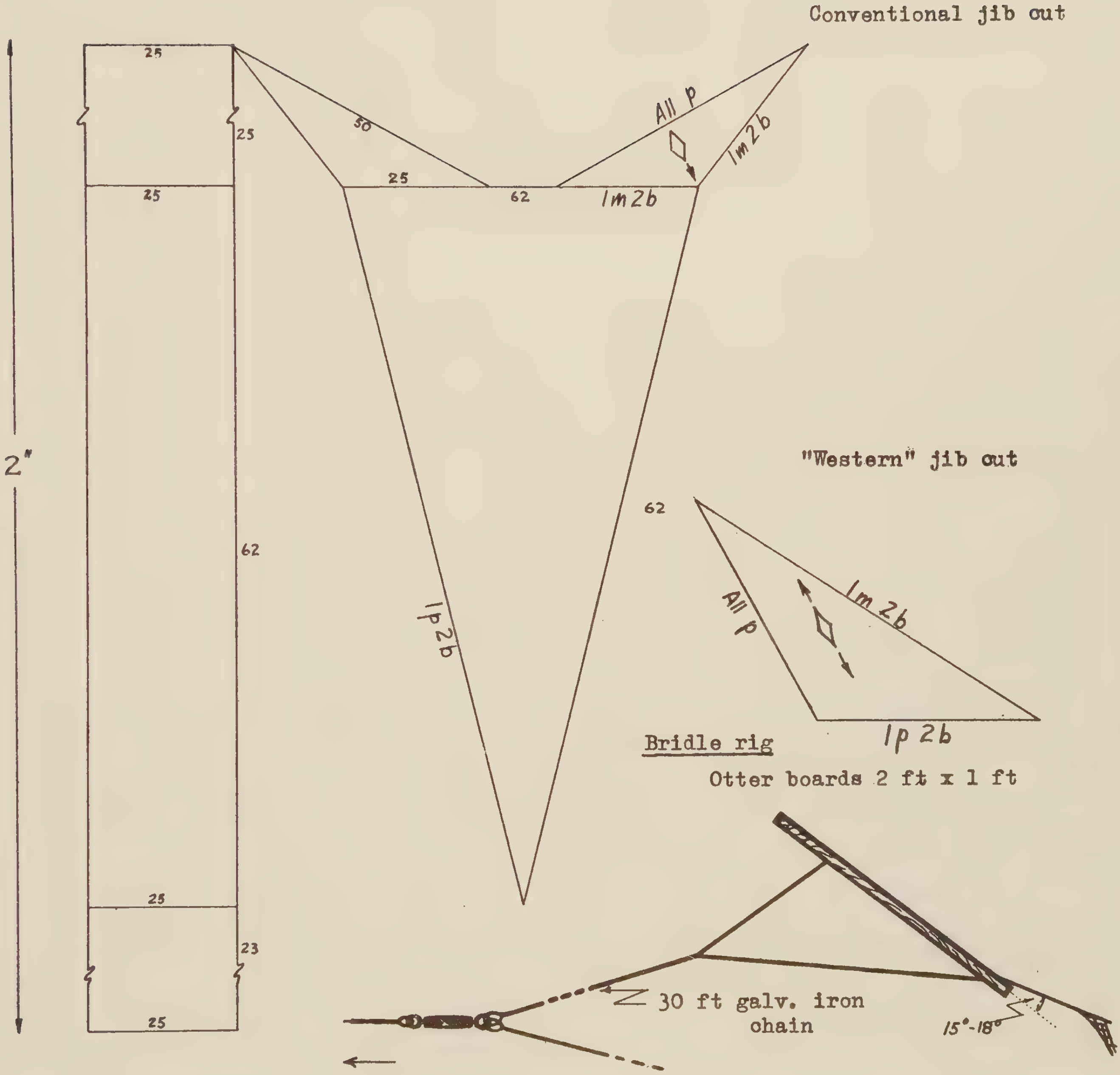

Fig. 12 Gulf of Mexico 16 ft trynet.

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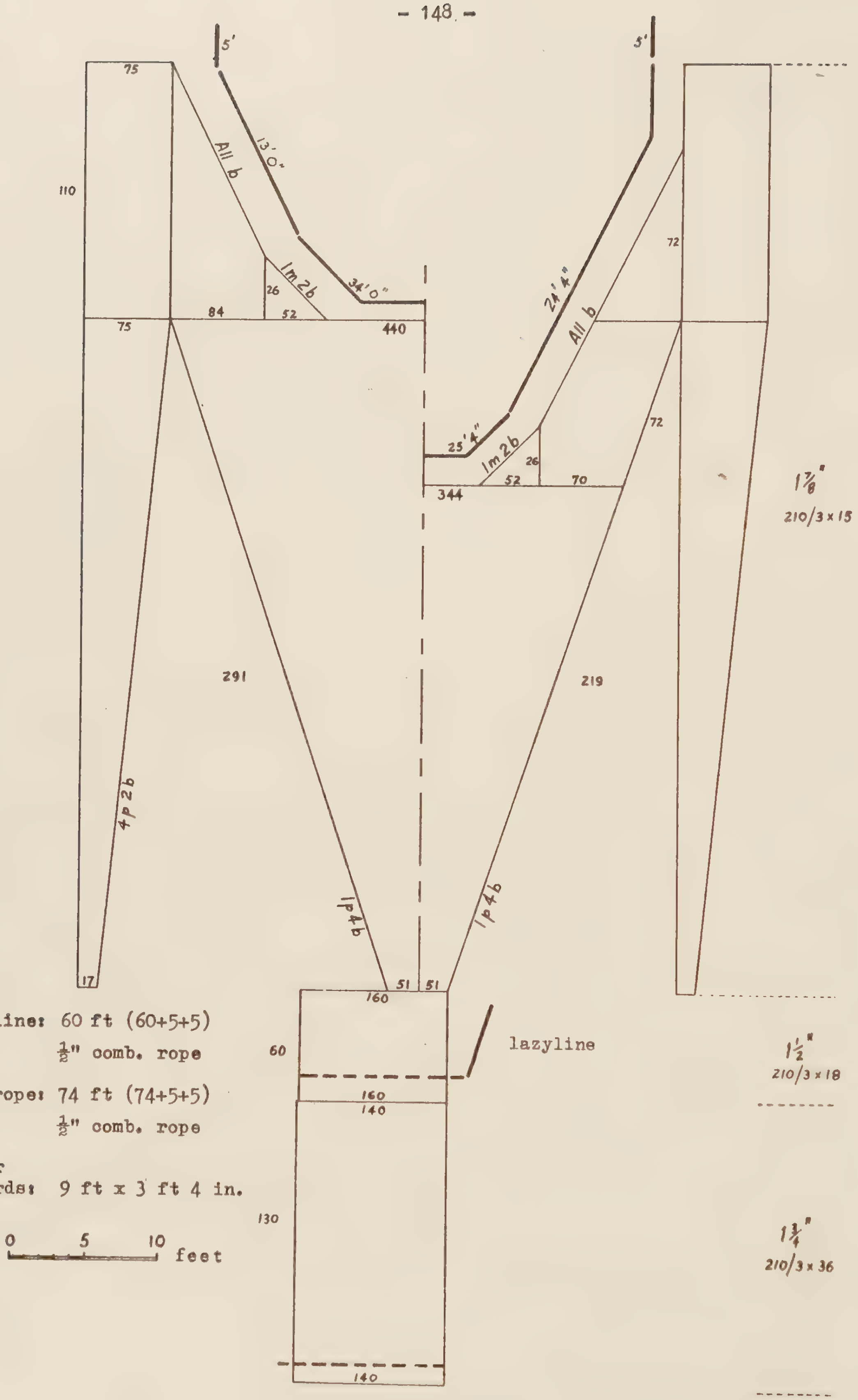
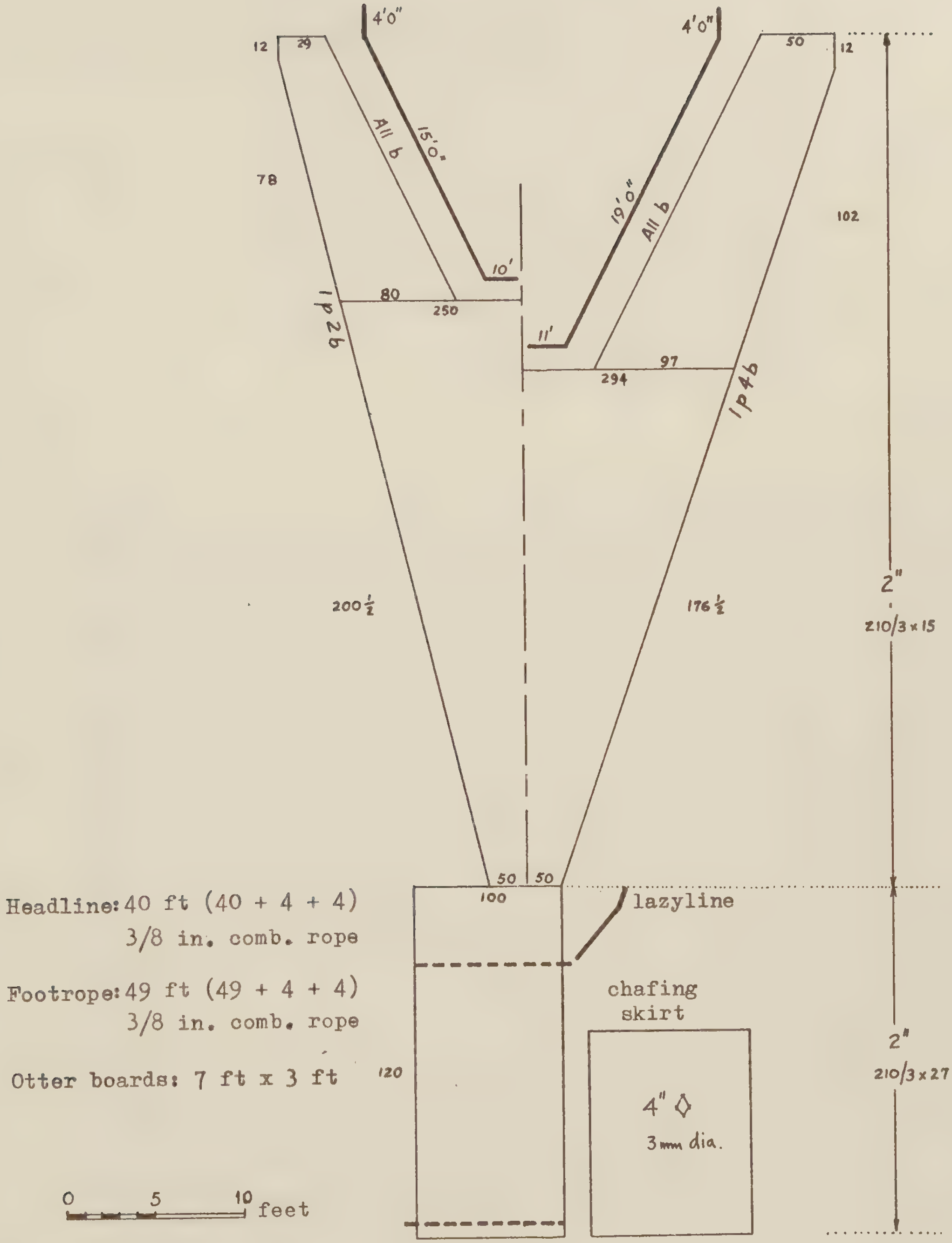


Headline: 60 ft (60+5+5)
½" comb. rope

Footrope: 74 ft (74+5+5)
½" comb. rope

Otter
boards: 9 ft x 3 ft 4 in.

Fig. 13 Gulf of Mexico 60 ft semi-balloon trawl.



Headline: 40 ft (40 + 4 + 4)
3/8 in. comb. rope

Footrope: 49 ft (49 + 4 + 4)
3/8 in. comb. rope

Otter boards: 7 ft x 3 ft

Fig. 14 Gulf of Mexico 40 ft two-seam balloon trawl.

ranging from 15 in (40 cm) of chain on 12 in (30 cm) spacings to 36 in (90 cm) of chain on 27 in (70 cm) spacings. The amount of chain (number of loops) used is extremely variable. Usually a few loops are placed at the forward ends of the wings, a few adjacent to the junction of the corner pieces and bosom, and a few in the center of the bosom. The use of continuous loops around the entire footrope is generally restricted to some vessels operating in the northern Gulf of Mexico.

The tickler chain is an innovation introduced in the Gulf shrimp fishery in the fifties and is used by virtually all vessels today. It is a chain of ¼ to 3/8 in diameter rod (6 to 10 mm), 2 to 3 ft (60 to 90 cm) shorter than the footrope. It is secured at the trawl boards or wings of the trawl and tows on the bottom ahead of the footrope for most of its length (the chain takes the form of a catenary, but the footrope shape is closer to a parabola). The purpose is to frighten shrimp off the bottom into the oncoming trawl. In addition to increasing the catch, the use of a tickler chain permits fishing the net a greater distance (higher) off bottom, reducing the trash catch.

Some fishermen use a "Texas drop-down" chain which serves both as a device for footrope weight and as a tickler chain. It is a chain running between the doors, much as a tickler chain, but is secured to the footrope at about 3-foot intervals by short lengths of "drop-down" chain. The drop-down lengths are usually equal in length for a given trawl but this length is variable depending upon fishing conditions. It is generally agreed that this is more effective than a tickler chain (when properly adjusted) but because its effectiveness is reduced by small increases in the chain length (due to wear and/or stretching) it has not been widely adopted.

The use of headline flotation is a minor factor in Gulf of Mexico shrimp fishing. The average number of plastic floats used is only 3 per trawl (Juhl, 1961).

In the north and western Gulf there are grounds where accumulation of mud in the trawls is a serious problem. In the past "mudropes" were used to alleviate this. These devices were constructed of rope or wire wrapped with used netting to a diameter of 5 or 6 in (about 15 cm) and secured directly to the footrope. In 1958 plastic mud rollers (Fig. 15) were introduced and have replaced the mudropes. These are cylindrical hard-shell plastic floats which have been drilled to eliminate floatation and they are strung on a line. The line is secured at intervals to the footrope. This device allows trawling on soft mud bottom but is not nearly as cumbersome as the heavy mudrope. Also "flying saucers" are used by some fishermen to combat the mudding problem. These are plywood discs 8 to 10 in in diameter reeved on the footrope at 6 to 8 ft (about 2 m) spacings. They serve to prevent bogging by causing the net to fish very light. Another aid is the use of very wide mud-shoes on the trawl boards.

All fishermen use chafing gear to protect the codend. In the southern Gulf, where the bottom is particularly abrasive due to shell and coral, the chafing gear is constructed from large mesh (4 in) (10 cm) codend cover made of polyethylene netting. Strands of about No. 18 to 36 polyethylene twine 18 in (45 cm) long are tied (at their mid point) to each knot of the codend cover. The cover completely envelopes the codend and is commonly referred to as a "hula skirt" (Fig. 16).

Trawl boards used in the Gulf of Mexico have changed little in design over the years, except that there is a trend toward larger boards for given trawl sizes. For example, some years ago 5 x 2.5 ft (1.5 x 0.7 m) boards were used on trawls in the 45 to 50 ft (14 to 15 m) class, 7 x 3 ft (2 x 0.9 m) boards on trawls to 80 ft (25 m) and 9 x 3.3 (2.7 x 1 m) boards on trawls to 100 ft (30 m). Today trawls of 40 to 50 ft (12 to 14 m) are fished with 7 x 3 ft (2 x 0.9 m) boards weighing about 200 lb (91 kg); 50 to 55 ft (15 to 17 m) trawls with 8 x 3.3 ft (2.4 x 1.0 m) boards; 55 to 65 ft (17 m to 20 m) trawls with 9 x 3.4 ft (2.7 x 1.0 m) boards and 70 ft (21 m) trawls with 10 x 4 ft (3 x 1.2 m) boards.

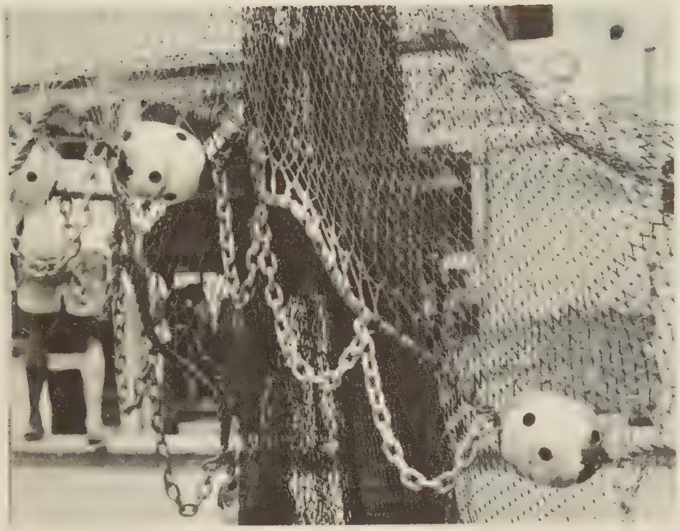


Fig. 15 Mud rollers and footrope chain.

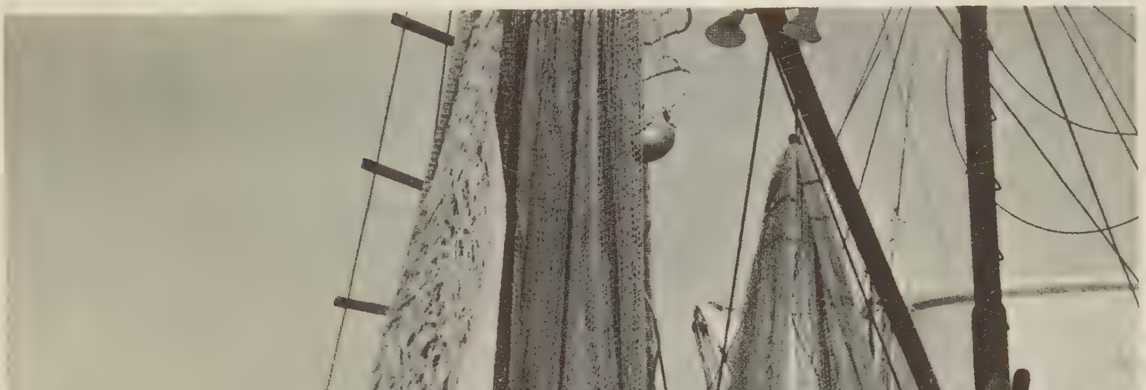


Fig. 16 "Hula skirt" chafing gear used in the Gulf of Mexico.

It is characteristic of the Gulf shrimp fishery for the boards to be slightly longer than twice their height. Chain bridles are still used for achieving the desired towing attitude. Normally the upper chains are one or two links longer than the lower ones, which gives the boards an outward tilt and downward thrust.

In double-rig trawling the trawl boards of each net are joined to the single towing warp with a bridle. The bridle length is approximately 25 fm (46 m) for nets in the 40 to 50 ft ranges, 40 fm (73 m) for nets to 60 ft and progressively longer for larger trawls. Bridle wires are $\frac{1}{4}$ to $\frac{1}{2}$ in diam., and wire sizes for towing warps range from $\frac{1}{2}$ to 5/8 in. Warp and bridle wire are of 6 x 7 preformed galvanised plow steel.

Most vessels in the Gulf area use 3-drum winches; one drum for each trawl warp and one for the trynet warp. They are normally powered from the main engine, either by direct mechanical drive or hydraulically. In recent years, some vessels have been equipped with 2-drum winches for the trawls and a separate small winch for the trynet.

3.1.5 Modes of operation Fishing operations in the Gulf of Mexico area can generally be classified as either local or long range. In local operations, vessels fish on grounds near ports of landing and return to these ports after an 8 to 12 day period to discharge catches and to re-provision. These are not necessarily the home ports of the vessels. Long range operations are those in which the vessels travel to distant grounds, where catches cannot be landed locally, and operate for periods from 6 to 12 weeks. In this case shrimp are shipped back to the home port every 6 to 8 days by other shrimp vessels which are completing their trips. Each vessel upon completing its last 6 to 8 day fishing period, prior to departing, loads shrimp from other vessels still operating. Commonly, stores such as fuel, ice, water and equipment are delivered to vessels on the grounds by vessels arriving from the home port. Vessels specifically for transporting shrimp and supplies are not used.

In addition to the migratory fleet described, there is a significant number of vessels (usually in the smaller size group) which seldom leave the grounds near their home ports. When yields fall to uneconomic levels they stop shrimping but may participate in other local fisheries.

3.1.5.1 Shrimp location The seasonal pattern of each fishing area of the Gulf is well known to the fishermen and is the primary factor in determining the area of operation at any given time. Generally, the migratory vessels follow a pattern of working the north and western Gulf during the summer and autumn and the Campeche and/or Tortugas grounds during the winter and spring. Timing of moves between general fishing areas is determined by communication with vessels already on the grounds and general knowledge regarding seasonal factors. Locating shrimp once the vessel is on a given ground is largely through experience, communication with other vessels and use of the trynet. Lighter marker buoys are used to mark exceptionally high shrimp concentrations. Location of shrimp through detection by echo sounders is not used, nor is inference of occurrence made through measurement of oceanographic parameters. However, all vessels use echo sounders to locate trawlable bottom, to remain in desired depths and to avoid trawling obstructions.

3.1.5.2 The fishing operation The major shrimp fisheries for brown and pink shrimp are largely night operations, because these shrimp burrow in the substrate during daylight and cannot be captured by conventional shrimp trawls. Normally fishing starts at sunset and stops at sunrise. During a tow, the trynet is hauled about every 20 to 30 min. This permits an estimate of both the trash and shrimp catch. On the basis of the trynet catches, a captain is able to stay in relatively high concentrations of shrimp or to move away from poor areas. Also, exceptionally large fish catches can be avoided; this is important since the fish slows down sorting of the saleable catch (and is discarded at sea).

Towing time is about 3 h on the average (but may range from 1 to 6 h), after which the trawls are hauled and the codends retrieved with the lazy-line. The lazy-line runs back from the inner trawl board to encircle the codend just behind the funnel (Fig.8). When the boards come up to the towing block on the outrigger boom, the lazy-line is reached with a long boathook and a bight of the line is hauled on a warping head on the winch. The codend is lifted with a whip line, the catch released on deck and the gear shot again immediately.

The catch is sorted by removal and simultaneous beheading of the shrimp. The trash consisting of miscellaneous fish species, sponges and crustaceans, is returned to the water. The shrimp tails are thoroughly washed and iced in the hold. If catches are very big, the shrimp are not beheaded but are iced heads-on. When this occurs the catch must be landed within 7 days, due to rapid deterioration of the shrimp resulting from the action of enzymes in the "head".

The fishery for white shrimp, in contrast to pink and brown shrimp, takes place largely by day. Whether the behaviour of white shrimp of foraging during daylight is a specific difference or is caused by environmental influences, such as water turbidity, is unknown. Except for the daytime factor, the method of operation and the gear is essentially the same as in the other fisheries. When the seasons and geographic areas are suitable, fishermen sometimes will work offshore at night for brown shrimp and inshore during the day for whites.

3.1.6 Major trends The major trend in this area is to larger, more powerful and better equipped vessels. Whereas the typical new vessel ten years ago was a 67 ft (20 m) wooden hull powered with 150 to 200 hp, today it is a 72 to 73 ft (22 m) hull with 250 to 300 hp. Also, 80 to 90 ft (24 to 27 m) vessels with engines to 500 hp are not uncommon in new construction today. Although wooden construction predominated in the past at a ratio of about 8:1, all-welded steel vessels are now reported to constitute 50 percent of new construction. The primary reason for this lies in the inherent ability of steel vessels to carry more fuel and water because the tanks can be built into the hull. Other reasons are the added strength-to-weight factor and availability of more effective anticorrosive compounds (Captiva, 1967). Other notable trends are the increasing use of hydraulic power for winches, steering and other units, better crew accommodation and freezing of the catch at sea.

Although introduced in the Gulf shrimp fishery during the fifties, it is only in recent years that freezing on board has been utilized to any extent. Two systems are presently in use, immersion freezing and static air freezing. The immersion systems utilize tanks on deck, for quick freezing and glazing in solutions such as salt and sugar. The air freezing system provides first for freezing, then for glazing after freezing is complete. The advantages of freezing on board are higher quality product (some freezer vessels receiving a premium price for their catch), increased fishing time since frequent unloadings are not necessary, and reduced crew labour in handling the catch.

Expanded polyurethane, instead of styrofoam, is being used to insulate fish holds, especially on the freezer vessels; and polyester clad combination rope is being introduced as material for headlines and footropes, replacing wire-manila.

3.1.7 New developments For a number of years both the United States Bureau of Commercial Fisheries and private industry have been working on the development of an electrical shrimp trawl (Wathne, 1964). The purpose of this system is to permit trawling for shrimp during daylight when they are normally buried and unavailable to conventional trawls (Fuss, 1964; Fuss and Ogren, 1966). The principle of the method is to stimulate the shrimp electrically so that they leave their burrows and can be taken in the trawl.

The various experimental designs have consisted of three basic system components: a source of electrical energy, a pulse generator for converting the source energy to the desired form, and an electrode array within the trawl gear to distribute the energy into the substrate.

Fishing results with the gear have been variable. In the north and west Gulf, daytime catches with an electric trawl have been consistently greater than 70 percent of night catches using standard gear in the same area. In the southeast Gulf (Tortugas grounds), daytime electric trawl catches have been generally only 30 to 50 percent of the night catches. The reasons for the different results in the two areas, as well as for the less than 100 percent effectiveness, are apparently directly related to response patterns exhibited by the shrimp under conditions of relatively high light level and visibility which enables them to avoid capture. There are hopes of resolving this problem, and development work continues.

3.2 Northeast coast of South America

Historically the shrimp fisheries in this area (Guyana, Surinam, French Guiana and northeast Brazil) have been confined to inshore grounds near or within the many major river drainage systems of the coast. The principal species taken in these inshore fisheries is the sea bob (Xiphopenaeus kroyeri). In addition, Penaeus aztecus and Penaeus schmitti are taken in most of the areas. There is also a significant fishery for two very small shrimp, Palaemon schmitti and Hippolysmata oplophoroides, in Guyana, and it is largely restricted to this area (Lindner, 1957). Marketing of catches from all of these inshore fisheries is local, the shrimp being mostly dried or semi-dry. The larger species are marketed fresh.

The traditional inshore fishery depends largely on static gear of various types, including Chinese trap nets and stop seines. The trap nets are pyramid-shaped, measuring 15 to 20 ft (4.5 to 6 m) square at the mouth tapering to 2 or 3 ft (0.6 to 0.9 m) at the bag. The sides of the mouth are suspended between two fixed vertical poles, and the bottom edge is pushed into the mud and held with poles. Suitable bracing of the vertical structures is provided by additional members. Normally several of these nets are constructed adjacent to each other and are fished on both incoming and outgoing tides. The stop seines consist of a series of upright stationary poles, between which is strung a wall of netting, usually 500 to 600 fm (about 900 to 1,100 m) long and 8 or 9 ft (2.4 to 2.7 m) high. It is fished only on the outgoing tide (Lindner, 1957).

In 1957 and 1958 the U.S. Bureau of Commercial Fisheries conducted two exploratory fishing surveys in the international waters of this area. The first cruise covered the general region extending from Trinidad to the Amazon River, and the second cruise was largely devoted to a more detailed investigation of a smaller area off the coasts of Guyana (British Guiana), Surinam, and French Guiana (Bullis and Thompson, 1959). As a result of this survey, industry initiated trawling operations and has established processing plants in the three countries bordering the grounds, and also in Trinidad and Barbados. The current fleet working the grounds numbers over 200 modern shrimp vessels.

In contrast to the inshore fisheries, those offshore are primarily for pink shrimp (Penaeus brasiliensis) and to a lesser extent brown shrimp (P. aztecus). Fishing depths in the offshore grounds range from about 20 to 40 fm (37 to 73 m).

Due largely to the very strong currents and relatively heavy seas which characterize this area, "typical" vessels are larger and more powerful than in the Gulf of Mexico fishery. Vessels initially used were mostly of the 67 ft (20 m) class powered with up to 200 hp, but newer vessels coming into the fleet are largely 73 ft (22 m) hulls with up to 300 hp; 80 to 90 ft (24 to 27 m) vessels with up to 500 hp are not uncommon. The fishing gear is essentially as described for the Gulf of Mexico, the primary difference being that smaller otter boards and trawls are used for a given horsepower than in the Gulf. Trawls of 40 to 45 ft (12 to 14 m) (double-rig) on 7 x 3 ft (2.1 x 0.9 m) doors are common for 72 to 73 ft (22 m) vessels powered with up to 300 hp. It has been found that, in the strong currents and heavy seas, the smaller gear produces better catches than the larger gear which a vessel of the same size would use in the Gulf of Mexico. The method of operation is similar to that described for long range operations in the Gulf of Mexico. Fishing trips are usually 6 to 8 weeks and shrimp are shipped back for processing every 8 to 10 days. At present, vessels are working grounds as far south as the Amazon River. Due to the increasing distances between grounds and processing plants, the obvious advantages of freezing at sea are being recognized for the longer range operations. A number of vessels based in Trinidad have recently installed freezing systems. Virtually the entire pack is for the export market.

3.3 Persian Gulf

Shrimp fishing on a commercial scale started in 1959 with a fleet of seven boats based in Kuwait. These fishing units were transferred from the Gulf of Mexico, and both the boats and gear were of the type described on previous pages. By 1961 the production was estimated at about 3,000 t of frozen tails, and by 1964 about 6,000 t. By now there are three fishing companies with about 80 shrimp fishing vessels based in Kuwait. Many of the vessels have operated in Iranian waters under the terms of a special concession.

Lately shrimp fishing is also being conducted from Saudi Arabia, Bahrain, Qatar and Trucial Coast. The past few years have seen a rapid increase in foreign fishing vessels operating in international waters of the Gulf and today there are probably about 150 vessels engaged in shrimp fishing in the Persian Gulf area. These will soon include fleets of catcher boats of 70 ft (21 m), based on factoryships of up to 4,500 t. The total production in 1966 has been estimated at about 12,000 t ready frozen product.

Some of the vessels are small ones from 40 to 60 ft (12 to 18 m), operating mostly in the coastal waters and delivering their catch to motherships or to freezing plants ashore. These vessels carry their catches on ice and most of them have no mechanical refrigeration facilities.

Quite a number of vessels ranging from 70 to 180 ft (21 to 55 m), (Figs. 17 to 29), have modern freezing equipment and pack and freeze their catches on board the vessels. Some of these vessels also act as motherships for the smaller ones which do not have freezing facilities. The vessels are generally fitted with sorting troughs and automatic shrimp graders on deck, and freezing equipment below deck. Some of the boats have brine chilling tanks for shrimp caught in excess of freezing capacity (Fig. 20).

3.3.1 Fishing areas and seasons The best known shrimping areas in the Gulf lie along the Iranian side, although productive grounds are also found along the Arabian coasts and out in international waters. Fishing areas exploited so far are mostly in shallow waters from inside 4 fm (7 m) out to 50 fm (91 m) and mainly fairly close to shore.

In the best shrimping areas the bottom is muddy and the water turbid. Shrimp have also been found from time to time on hard bottoms with rock and coral, but fishing there is difficult due to heavy gear damage.

There seems to be a connection between the water temperature and the catches obtained, but so far the correlation has not been well established, except that shrimp are difficult to find during the very hot summer months and also during the coldest season in mid-winter.

Fig. 17
15 shrimp trawlers of widely different types and sizes undergoing repairs in Kuwait harbour.

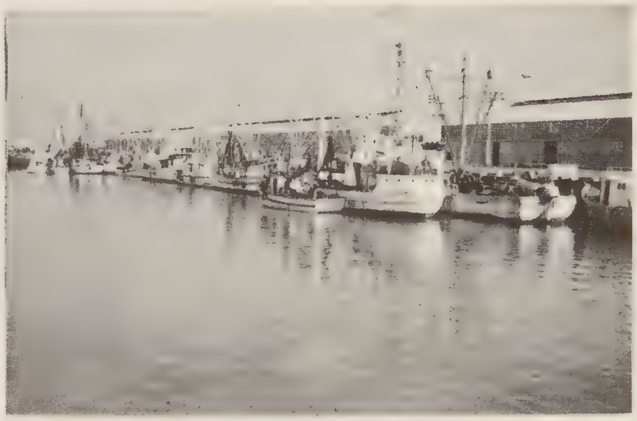


Fig. 18
A few of the shrimpers are built as side trawlers but all ships are fitted for Gulf of Mexico type double-rig trawling.

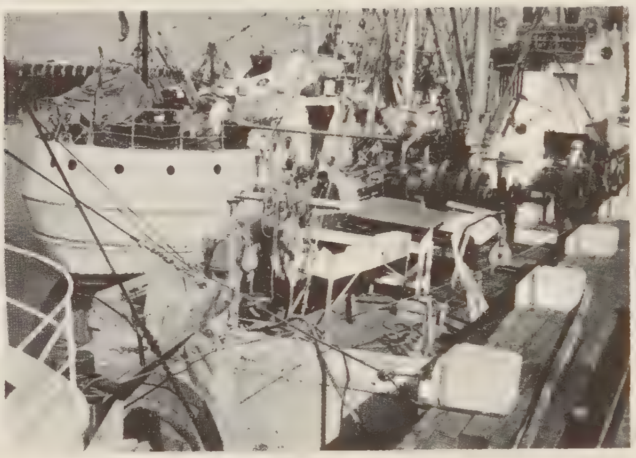


Fig. 19

Note small bobbins on footrope.

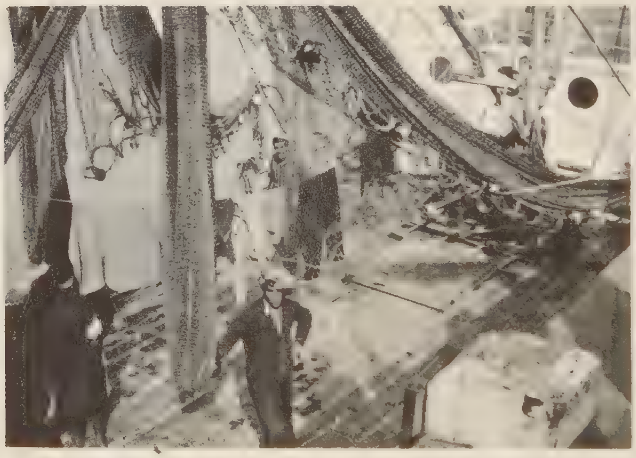
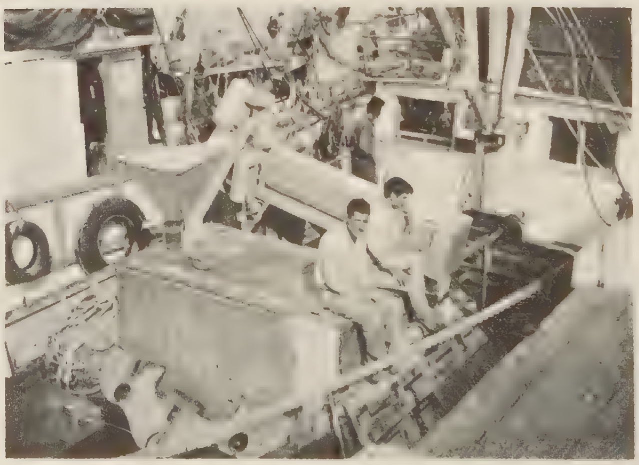


Fig. 20

Shrimp grader installed on deck. The boys sit on brine tank used for chilling shrimp caught in excess of freezing capacity of plate freezer below deck.



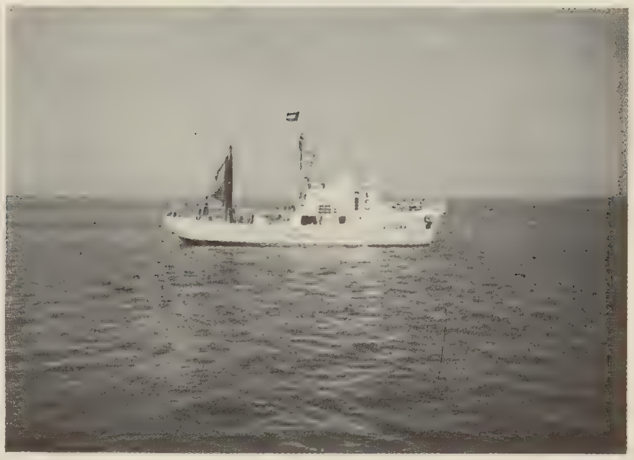


Fig. 21
One of a fleet of several 84 ft Norwegian-built shrimpers from Kuwait.

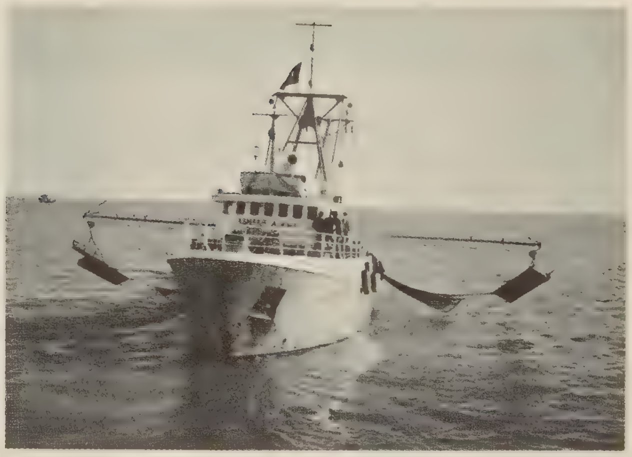


Fig. 22
When prospecting, these trawlers operate a flat trawl (60 ft footrope) on one side, a semi-balloon or balloon trawl (55 ft footrope) on the other side, and a small trynet over the stern.

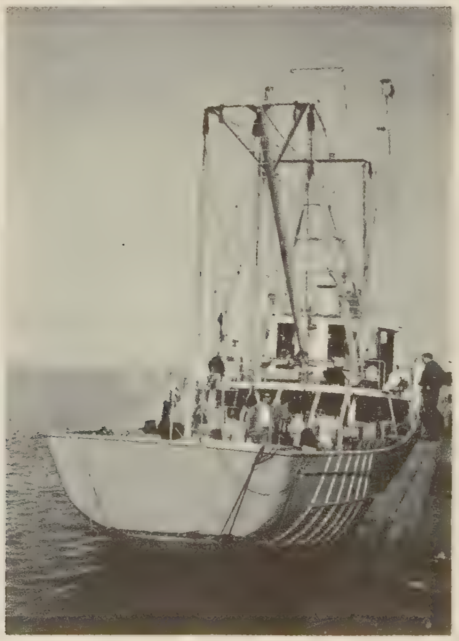


Fig. 23
The small davit on the stern is for the trynet warp.

Fig. 24

Ready to lower the gear.

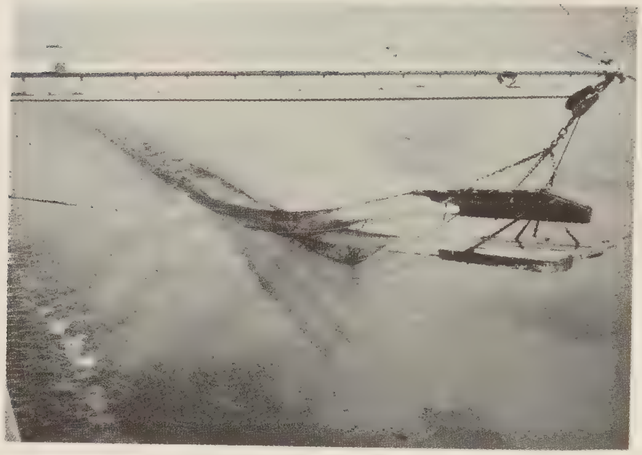
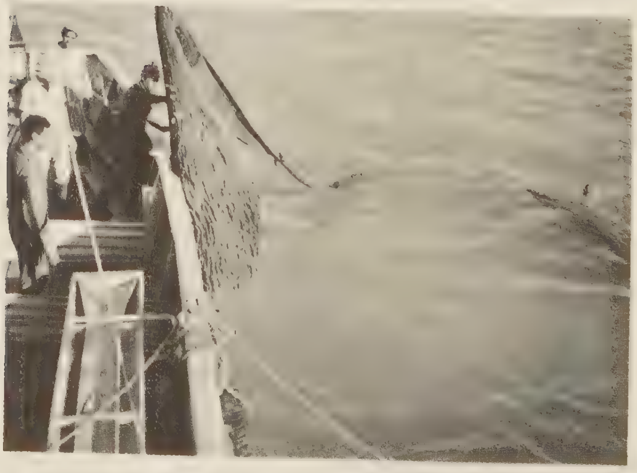


Fig. 25

Trawl boards squaring off.

Fig. 26

The codend hauled
on the lazy-line.



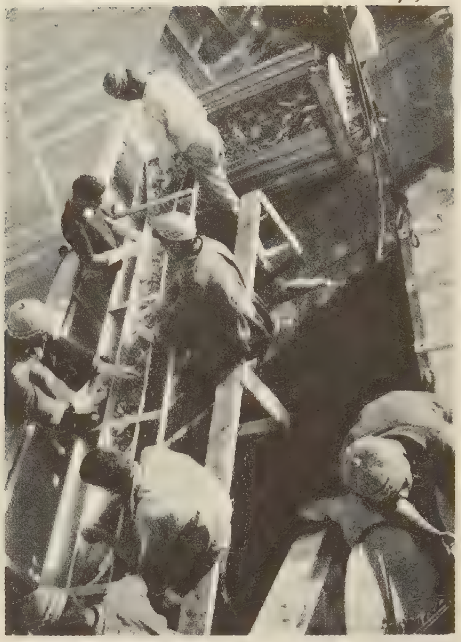


Fig. 27
The catch is sorted and heads torn off good-sized shrimps on two sorting troughs arranged along the railing on either side.

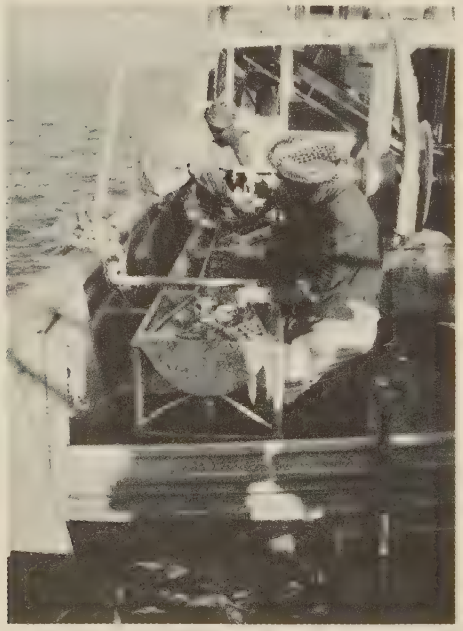


Fig. 28
Note automatic size grader in background.

Fig. 29
Transfer of provisions at sea.

The grounds which are found to be highly productive in one season one year often give practically no catch the next year. There also seem to be drastic changes in catch rates in the same areas from day to day and the ships operating offshore are constantly exploring. Fishing goes on both night and day. The best fishing is usually during spring and autumn, although the 1966 spring season was comparatively poor. Catch rates from this region are generally the highest in the world.

3.3.2 Shrimp finding No systematic exploratory fishing has been carried out, and hardly any exchange or pooling of information takes place between the companies. Consequently knowledge of major seasonal migrations is scattered among the various skippers, who generally seem to feel that the less they tell the better they are off. Yet, two or more vessels from the same company often exchange information while fishing.

Various methods of locating fish are used in the area. Most, or perhaps all, of the vessels are equipped with echo sounders, and these, in conjunction with trynets, are the major shrimp finding tools. It takes an observant skipper to interpret the echo traces correctly. An experienced man can in most cases decide whether the echo sounder shows shrimp or fish, or whether a difference in the bottom echo is due to a change in bottom conditions or a layer of shrimp at the bottom. However, broadly speaking, it is probably fair to say that in shrimp location the best results are obtained when echo records are interpreted in close conjunction with indications obtained with the trynets, coupled with exchange of information over the radio telephone among vessels operating together. Fig. 2 illustrates an unusually clear recording of shrimp on or near the bottom obtained with an echo sounder with white line feature working at 38.5 kc/s. Even when shrimp traces are not obtained, a white line echo sounder may give good guidance in the location of likely shrimp fishing grounds through bottom discrimination.

A few of the most modern vessels have Decca Navigation equipment and Track Plotters which greatly help to relocate positions of shrimp schools limited to a very small area.

3.3.3 The shrimp The catches comprise all sizes from less than 15/lb (33/kg) headless, to about 150 to 200/lb (330 to 440/kg). Only sizes down to 51/60 headless /lb (112 to 132/kg) are utilized for the U.S.A. market. Smaller shrimp have so far been mostly thrown overboard, but some of the shrimping operators are now starting to utilize the smaller size shrimp for other markets. As the big shrimp give the best price, it is only natural that fishing activities concentrate on these. Landing statistics are not available, nor is reliable information about species composition.

3.3.4 The gear Flat trawls of Gulf of Mexico type are used, in sizes ranging from 40 to 110 ft (12 to 34 m), semi-balloon and balloon trawls from 54 to 75 ft (16 to 23 m); also Scandinavian shrimp trawls of 2-seam and Danish design are used. Most of these trawls are described in the preceding chapter on the Gulf of Mexico and a later chapter describing Norwegian shrimping.

3.4 West Africa

The geographic features of Africa's west coast from Dakar to the Congo River and the results of limited exploratory work suggest that a significant potential for a shrimp trawl fishery may exist in this large area. In several of the West African countries, shrimp constitutes a part of the trawl catch in inshore waters, as well as being taken by various traditional local fishing gears, such as beach seines, traps, etc. So far the only specialized, modern shrimp trawl fishery is in Nigeria, and this is briefly described here below. The trap fishing gear used in the Dahomey lagoons also warrants description as an illustration of traditional shrimp catching methods.

3.4.1 Nigeria In 1956 a fleet of inshore trawlers, varying in number from one to thirteen, worked out of Lagos and took small quantities of penaeid shrimp incidental to the fish catches (Raitt and Niven, 1965). However, it was not until May 1964 that otter trawling specifically for shrimp was initiated. At that time the Spanish trawler VILLA SANTA POLA was supplied with a Gulf of Mexico shrimp trawl by the United States Agency for International Development, and the method of working the gear was demonstrated by an FAO fishing technologist. Initial fishing trials were very successful and led to commercial shrimp fishing operations in which several vessels now engage.

At present, the only species taken in significant quantities is the pink shrimp (P. duorarum) although small quantities of a small species (Parapenaeopsis atlantica) are taken on shallower grounds off Lagos. Pink shrimp are known to occur along the entire coast inside 25 fm (46 m) although the heaviest concentrations have been found in the 5 to 15 fm (9 to 27 m) depth range. Also, quite promising catches of red prawn (Plesionika sp.) have been made during exploratory fishing activities in water depths from 400 to 600 m (220 to 330 fm) (Raitt and Niven, 1965). On the basis of present knowledge it is estimated that about 3,000 square miles (7,500 km^2) of trawlable grounds exist off Nigeria within the 25 fm (46 m) curve. In addition, an unknown shrimp potential exists in deeper waters.

The newly established inshore shrimp trawl fishery is a year-round one, with peak production occurring during the rainy season and the following months (June-December). Fishing operations are productive both night and day. However, during the dry season (February-May) night catches are up to 60 percent greater than during the day. This is especially the case on clear moonlight nights. Just preceding and during the rainy season, when the sea becomes more turbid, day and night results are similar. Also, it has been found that during this season night catches are increased by using high-opening trawls.

Shrimp appear to occur in local concentrations on the grounds. Catch rates have varied considerably on the same grounds during the same day. This is consistent with patterns found in other penaeid shrimp fisheries, and is a strong argument for use of the trynet if yields are to be maximized.

3.4.1.1 Fishing vessels and gear At present, the fishery is a small one with only 9 or 10 double-rigged vessels. These range in size from a 71 ft (22 m) 220 hp vessel to a 110 ft (34 m) 835 hp freezer trawler. Six of the vessels are equipped to grade and freeze the catch aboard. The other vessels ice the shrimp tails and deliver them to port each 2 to 3 days. The fleet is now being expanded with new and modern vessels.

The trawling gear is similar in design and construction to that described for the Gulf of Mexico area.

In contrast to most other shrimp fisheries, the catch of marketable fish constitutes a very significant part of total revenues. It is estimated that these vessels are now taking approximately 30 to 36 t of shrimp and 120 t of marketable fish monthly. The total value of the fish is about half that of the shrimp.

In addition to the above mentioned exploratory and development work off Nigeria, some very limited but promising tests have been made recently with a Gulf of Mexico trawl off the Ivory Coast. Trawling with a 60 ft (18 m) semi-balloon trawl produced about 1,700 lb (770 kg) of shrimp in two days and one night of fishing, with higher catch rates during the day. The daytime rates of shrimp catch were 3 to 10 times greater than locally based commercial trawlers, fishing for market fish and shrimp with European type trawls, were getting in the area at the time.

3.4.2 Dahomey In Dahomey a system of traps is used in lagoons to capture shrimp which are migrating to the sea. Fig. 30 shows the arrangement of the fishing units and the layout of each trap within a unit. Each trap system is made up of approximately 25 individual traps. The leads or wings on each trap are constructed from palm leaves framed with palm sticks which are secured in the bottom. They taper back to a trap chamber, above which is placed a parafin lamp for attracting the shrimp. The traps face the ebb tide and fishing is only at night when the shrimp are active. In the largest lagoon in Dahomey there are 160 trap systems comprising about 4,000 individual traps. Each system catches approximately one ton of shrimp (P. duorarum) and a similar amount of crabs per year. Very few fish are taken.

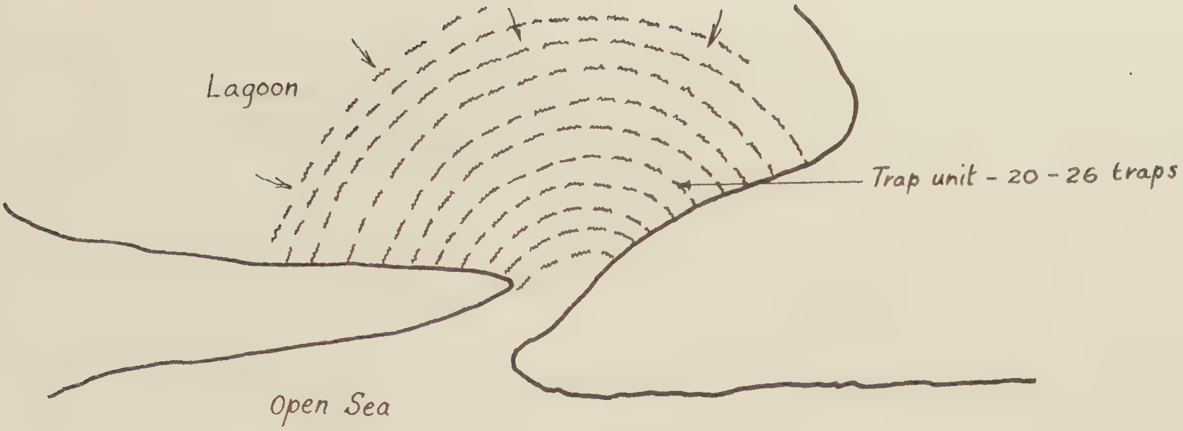
The trap system used in Dahomey is similar to other lagoon shrimp fisheries in Africa.

3.5 India

India is a good example of a tropical country where shrimp trawling has been introduced in recent years, and the commercial fishery is still in a stage of early evolution.

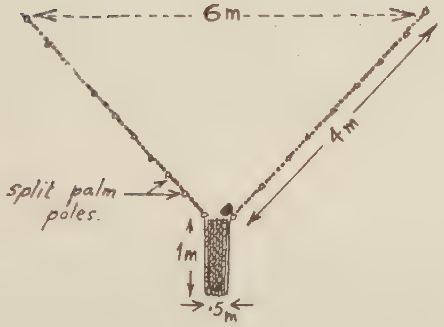
With shrimp production estimated at 50,000 to 80,000 t annually, India was already one of the world's leading shrimp producers before mechanized fishing was introduced - mainly in the last 10 years. The bulk of the shrimp catch, was and still is, caught in ponds, backwaters, canals, lagoons, and close inshore waters, and a big proportion of this is very small juvenile shrimp, much of which is sun dried. During the spring, at the beginning of the southwest monsoon, shrimp schools are observed on the surface, especially off the southwest coast, and have been traditionally caught in lampara-like nets (Kolli-Vala, Thuri-Vala). These nets have a long floatline but a relatively short leadline, so the net forms a kind of apron under the fish, when the wings are hauled to the canoes or log rafts.

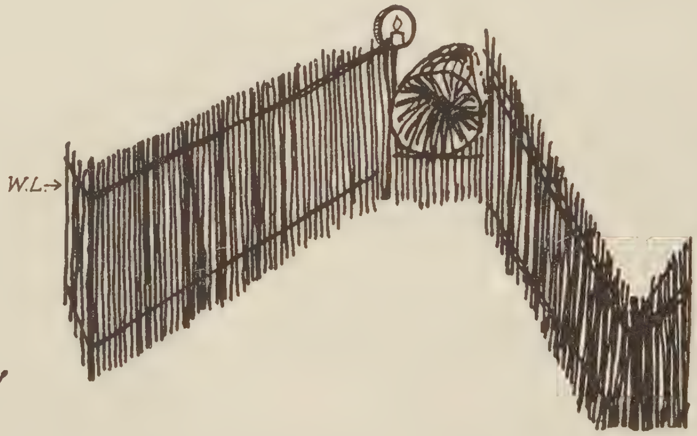
In 1955 an FAO Technical Assistance expert conducted experimental shrimp trawling with a 22 ft (6.7 m) 10 hp open motorboat off the Malabar Coast, using a Gulf of Mexico type flat trawl of 32 ft (9.7 m) headline. He obtained consistently impressive catch rates of shrimp in shallow inshore waters, in from 2 to 10 fm (4 to 18 m) depth. The slope of the bottom there is only about 1 to 1½ fm per mile (about 1 to 1.5 m/km), so that this was a fairly broad belt, and he found good shrimp catches everywhere along the 110 miles (200 km) stretch of the coast which he explored from Calicut to Mangalore. This was duly recorded in monthly reports sent by the expert and FAO to the competent authorities, but without creating any noticeable interest. FAO then issued a press release which, in the title, heralded these shrimp grounds as a "Gold Mine". This echoed through the world press and appeared in some 400 to 600 newspapers and periodicals, causing a parliamentary enquiry in India and a widespread interest in international shrimp business circles. This new-found realization of the shrimp trawling potential in fishing grounds, which had for ages been yielding impressive catches by primitive traditional methods, coincided with a governmental development program calling for the building of a considerable number of small motor boats, 25 to 30 ft (8 to 9 m), to be operated out of river mouths, havens and harbours on the Indian coasts. Fairly soon the first shrimp freezing plants were put into operation in Cochin and elsewhere on the Malabar Coast, and now there are perhaps around 2,000 small motor boats, mainly of 25 to 36 ft (8 to 11 m) in length, and 20 to 60 hp, trawling for shrimp. The bulk of the frozen shrimp is exported, yielding an annual revenue of about US.$10 million. Thus, the title of the "Gold Mine" press release proved prophetic. This story illustrates that often it is not enough to conduct exploratory or experimental fishing and record the results in technical reports. In this instance publicity was needed to start the ball rolling.



Single Trap

Plan





Detail

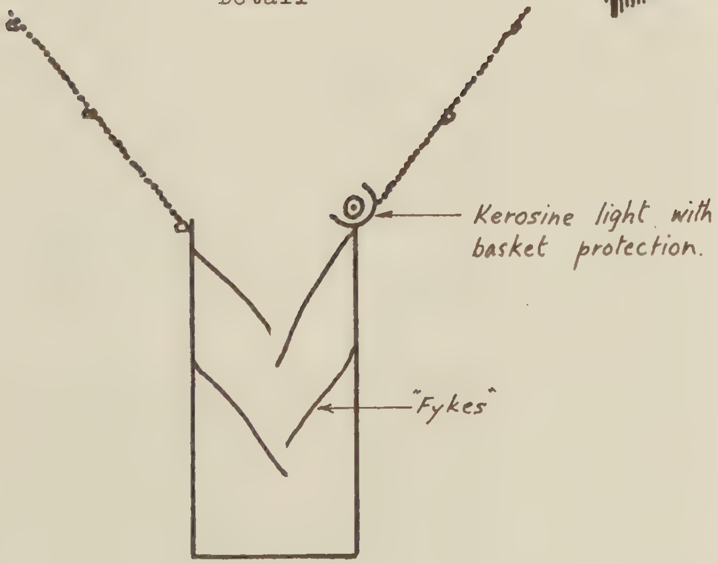


Fig. 30 Shrimp trap system used in Dahomey and other west African countries.

Fishing is still confined to within 15 fm (27 m), and even largely within 10 fm (18 m), not only due to the small size of the boats but mainly because lower unit catches of shrimp have been obtained so far in deeper waters. This seems to be fairly common in tropical countries. It must, however, be stressed that in India and many other tropical areas, deeper waters beyond 40 to 50 fm (73 to 91 m) have not yet been explored to any extent, either for shrimp or fish.

Shrimp species caught are: *Penaeus indicus*, *P. monodon*, *P. merguiensis*, *Metapenaeus dobsoni*, *M. affinis*, *M. monoceros*, and various species of *Parapenaeopsis*.

Figs. 31 and 33 illustrate the boats and deck arrangements commonly used in India. These boats are being series-built in great numbers in several shipyards both on the west, south and east coasts. So far only a few of the boats have mechanically-driven winches. On most boats the nets are towed by ropes instead of wire warps and are hauled by hand.

The trawls illustrated in Figs. 32 and 34 are commonly made of locally produced cotton twine, although nylon is gaining ground. The nets are variants of Gulf of Mexico type nets with minor modifications. Boats of 30 to 32 ft (about 9 m) and 30 hp normally use flat nets of 40 to 45 ft (12 to 14 m) with 24 x 42 in (61 x 107 cm) otter boards weighing 70 to 80 lb (32 to 36 kg). The bigger boats of 36 ft (11 m) and 60 hp use nets of 60 to 70 ft (18 to 21 m) with 25 x 55 in (0.63 to 1.40 m) otter boards weighing 100 to 120 lb (45 to 54 kg).

These small, decked motorboats of 25 to 36 ft (8 to 11 m) do not normally carry ice but bring in the catch each evening. Fishing is almost entirely limited to daytime. This day fishing pattern limits drastically the range of the boats to a small area near their home port. Plans call now for building bigger shrimp trawlers of 45 to 55 ft (14 to 17 m) which can stay at sea for a few days, ice the catch in insulated holds and exploit virgin grounds outside the small heavily-fished areas in the immediate vicinity of the harbours.

Shrimp is found along almost the entire west coast of India and West Pakistan, and on such areas in the east coast as have been explored so far.

3.6 Norway

The following description of shrimp fishing in Norway applies to a large extent also to shrimping elsewhere in Scandinavia and Greenland for *Pandalus borealis*.

3.6.1 *Grounds and shrimp species* Single-rig otter trawling for shrimp started in 1899 as a result of research by scientists of the Norwegian government (Hjort and Ruud, 1938). Until 1945, the fishery remained concentrated in southern Norway, but after World War II spread northward as far as the grounds bordering on the Atlantic Ocean between 70° to 71°N. Exploratory fishing by both government research vessels and the fishing industry is continuing.

While some other species of shrimp are also found in Norwegian waters, *Pandalus borealis* is the only one of commercial value. The habitat of this species is in cool deep water with occasional occurrences in shallow areas. Commercial fishing is conducted in depths from 30 to 300 fm (55 to 550 m), but experimental fishing has shown that shrimp occur down to at least 500 fm (910 m). They are primarily found on soft clay or mud bottom in deep fjords or in depressions on offshore banks. The temperature range of occurrence is 2 to 8°C but there are geographic optimums within this range. In the south it is 6 to 8°C, in the north 4 to 6°C, and in the Arctic (off Spitsbergen) 2 to 4°C. The shrimp are very sensitive to rapid temperature changes. If there is a sudden inflow of cold water at the bottom, as occurred in southern Norway in 1965 when the temperature fell 2°C, the shrimp leave the area but may gradually return when the

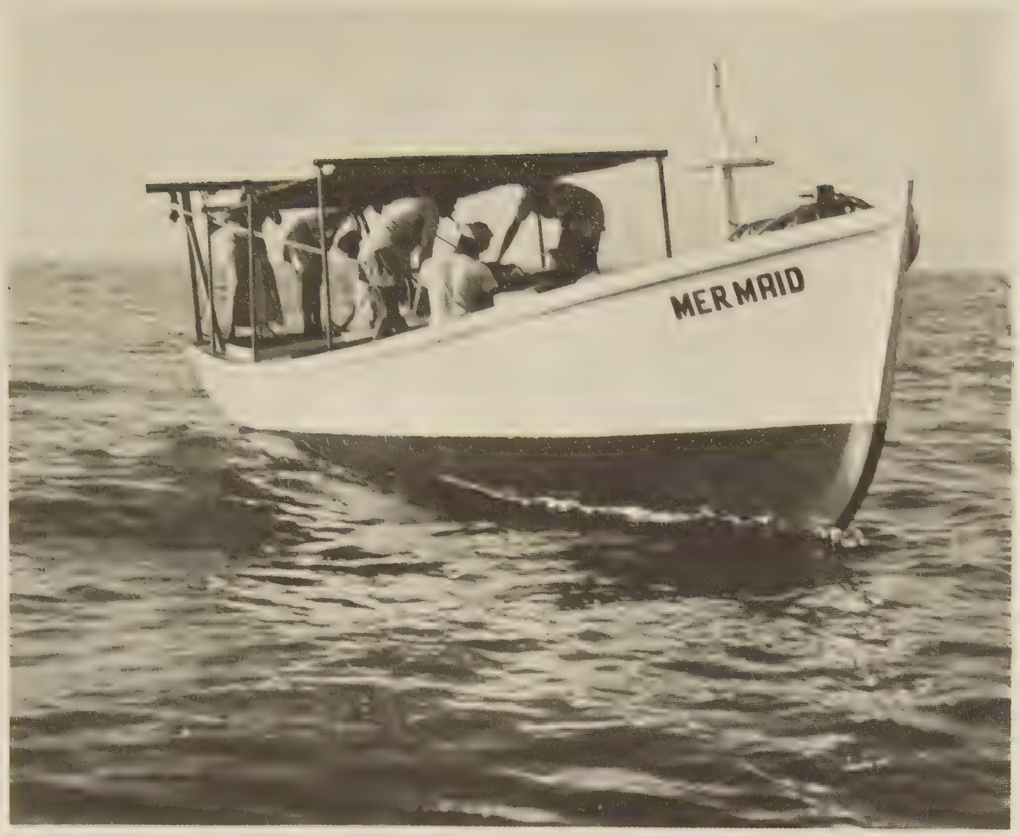


Fig. 31 A 32 ft Indian shrimp trawler, powered by a 30 hp engine.

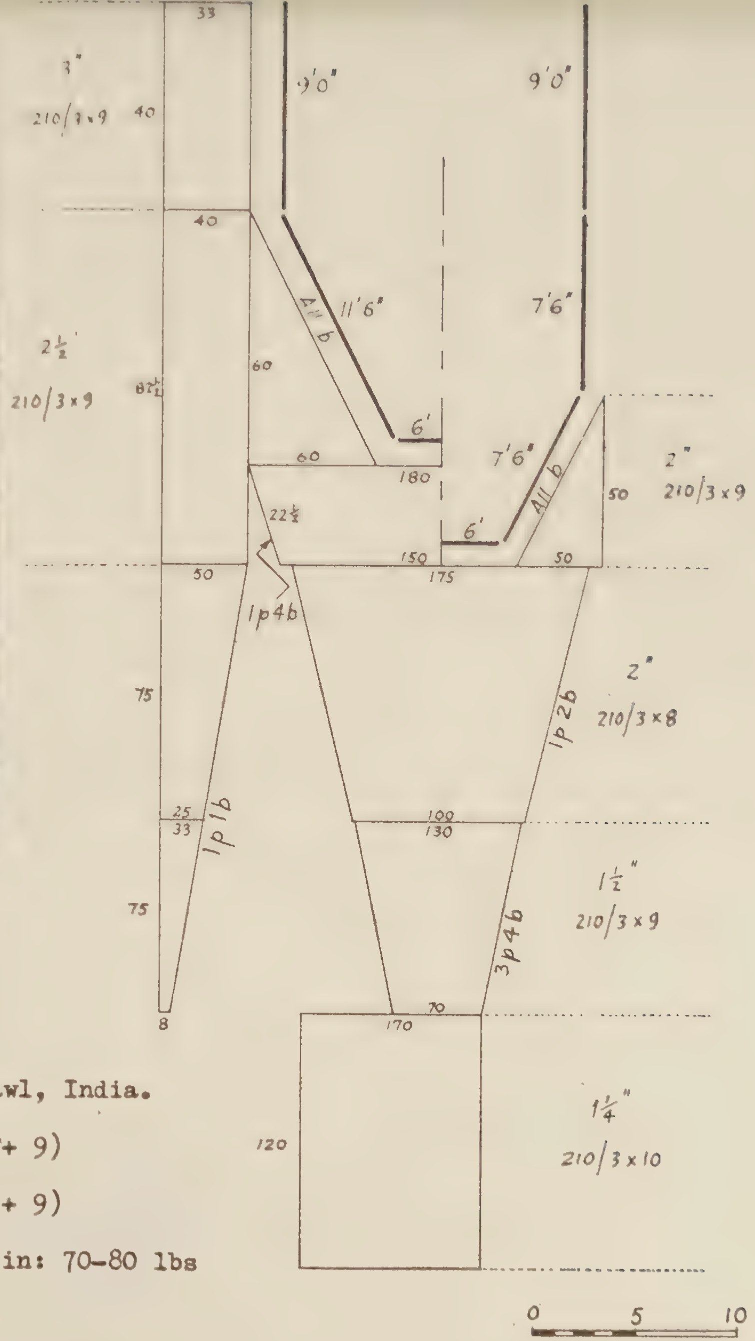


Fig. 32 A 47 ft four-seam shrimp trawl, India.

Headline : 47 ft (47 + 9 + 9)

Groundrope : 52 ft (52 + 9 + 9)

Otter Boards : 42 in x 24 in: 70–80 lbs

Vessels : 30 ft, 30 hp

(Kuriyan, Satyanarayana, Nair, 1966, Proc.Indo-Pacif.Fish.Coun., 11(2):213)

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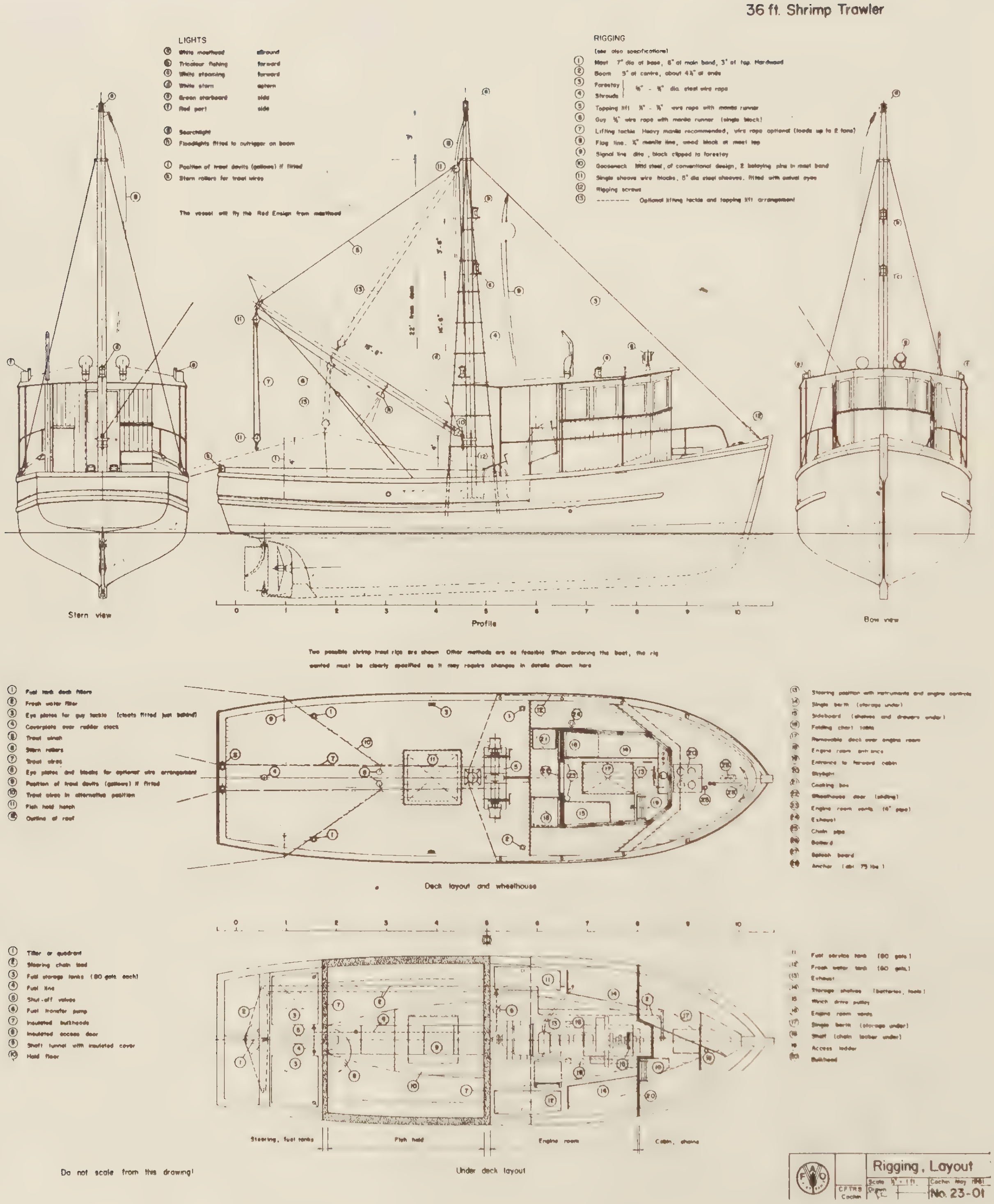
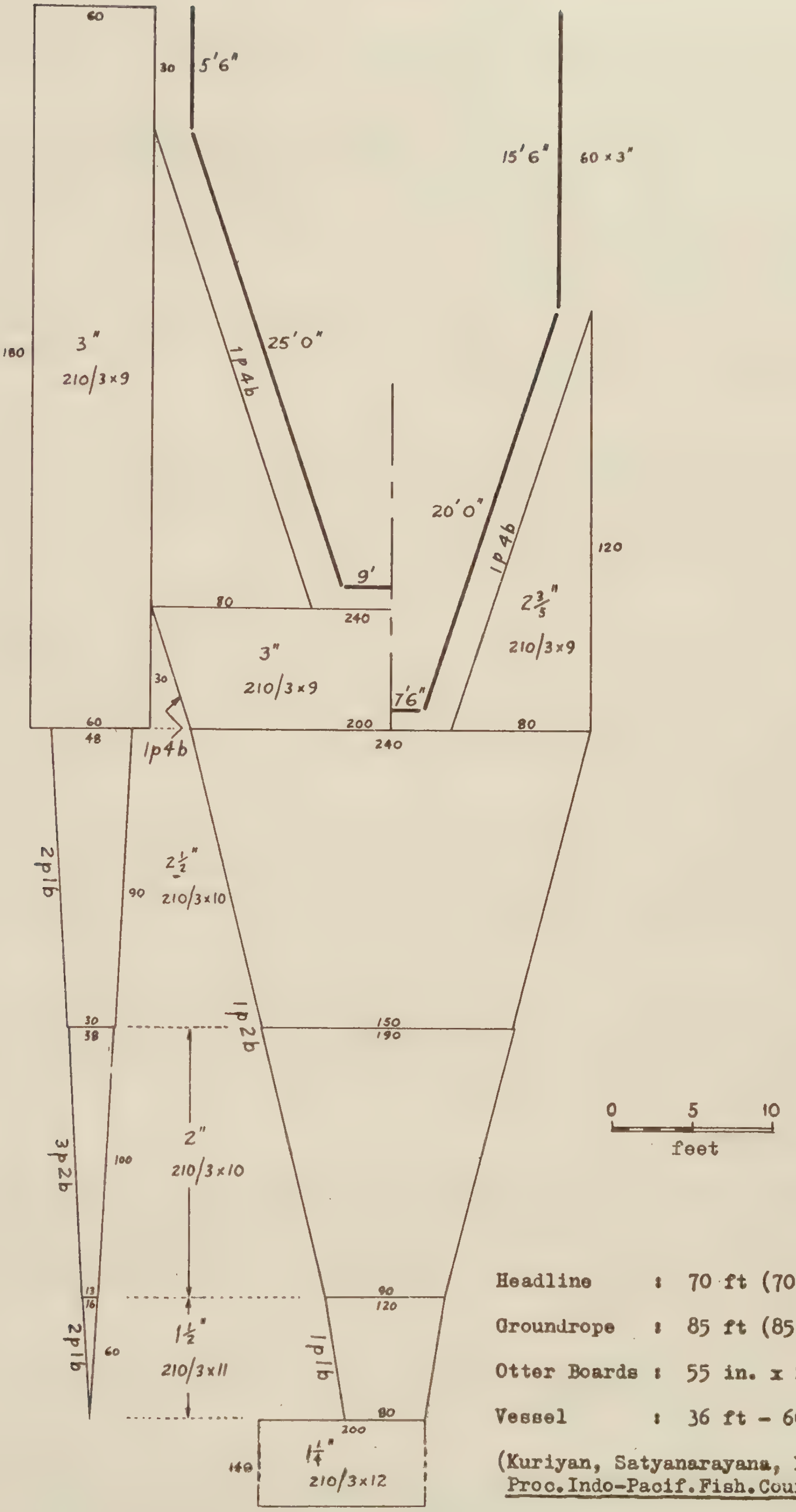

36 ft. Shrimp Trawler
LIGHTS
ⓐ White masthead — allround
ⓑ Tricolour fishing — forward
ⓒ White steaming — forward
ⓓ White stern — astern
ⓔ Green starboard — side
ⓕ Red port — side
ⓖ Searchlight
ⓗ Floodlights fitted to outrigger on boom
ⓘ Position of trawl davits (gallows) if fitted
ⓚ Stern rollers for trawl wires
RIGGING
(see also specifications)
① Mast 7" dia at base, 6" at main band, 3" at top. Hardwood
② Boom 5" at centre, about 4½" at ends
③ Forestay
④ Shrouds
⅜" - ½" dia. steel wire rope
⑤ Topping lift ⅜" - ½" wire rope with manila runner
⑥ Guy ⅜" wire rope with manila runner (single block)
⑦ Lifting tackle Heavy manila recommended, wire rope optional (loads up to 2 tons)
⑧ Flag line. ½" manila line, wood block at mast top
⑨ Signal line ditto, block clipped to forestay
⑩ Gooseneck Mild steel, of conventional design, 2 belaying pins in mast band
⑪ Single sheave wire blocks, 6" dia steel sheaves, fitted with swivel eyes
⑫ Rigging screws
⑬ -------- Optional lifting tackle and topping lift arrangement
22' from deck
16'-6"
Stern view
Profile
Bow view
0 1 2 3 4 5 6 7 8 9 10
① Fuel tank deck fillers
② Fresh water filler
③ Eye plates for guy tackle (cleats fitted just behind)
④ Coverplate over rudder stock
⑤ Trawl winch
⑥ Stern rollers
⑦ Trawl wires
⑧ Eye plates and blocks for optional wire arrangement
⑨ Position of trawl davits (gallows) if fitted
⑩ Trawl wires in alternative position
⑪ Fish hold hatch
⑫ Outline of roof
⑬ Steering position with instruments and engine controls
⑭ Single berth (storage under)
⑮ Sideboard (shelves and drawers under)
⑯ Folding chart table
⑰ Removable deck over engine room
⑱ Engine room entrance
⑲ Entrance to forward cabin
⑳ Skylight
㉑ Cooking box
㉒ Wheelhouse door (sliding)
㉓ Engine room vents (4" pipe)
㉔ Exhaust
㉕ Chain pipe
㉖ Bollard
㉗ Splash board
㉘ Anchor (abt 75 lbs)
Deck layout and wheelhouse
① Tiller or quadrant
② Steering chain lead
③ Fuel storage tanks (80 gals each)
④ Fuel line
⑤ Shut-off valves
⑥ Fuel transfer pump
⑦ Insulated bulkheads
⑧ Insulated access door
⑨ Shaft tunnel with insulated cover
⑩ Hold floor
⑪ Fuel service tank (80 gals)
⑫ Fresh water tank (60 gals)
⑬ Exhaust
⑭ Storage shelves (batteries, tools)
⑮ Winch drive pulley
⑯ Engine room vents
⑰ Single berth (storage under)
⑱ Shelf (chain locker under)
⑲ Access ladder
⑳ Bulkhead
Steering, fuel tanks
Fish hold
Engine room
Cabin, chains
Under deck layout
Rigging, Layout
Scale ½" = 1 ft.
Cochin May 1961
CFTRS Cochin
Drawn
No. 23-01

The vessel will fly the Red Ensign from masthead

Two possible shrimp trawl rigs are shown. Other methods are as feasible. When ordering the boat, the rig wanted must be clearly specified as it may require changes in details shown here.

Do not scale from this drawing!

Fig. 33 A 36ft 60 hp shrimp trawler as used in India.



Headline : 70 ft (70 + 14 + 14)

Groundrope : 85 ft (85 + 14 + 14)

Otter Boards : 55 in. x 25 in, 100-120 lb

Vessel : 36 ft - 60 hp

(Kuriyan, Satyanarayana, Nair, 1966, Proc.Indo-Pacif.Fish.Coun., 11(2):213)

Fig. 34 70 ft Four-Seam Trawl Net as used in India.

temperature conditions become normal. In the Arctic the shrimp will leave an area when the temperature falls below 0°C.

3.6.2 Shrimp finding Although it is known that *P. borealis* is a cold water species occurring at temperatures below 8°C, bottom temperatures are not used as a guide by the fishermen. Also, echo sounding is not employed directly for shrimp location but is used to evaluate likely bottom types. Strong echo sounders working at medium frequency (30 to 50 kc/s) with good bottom penetrating ability are of great help. The likeliest bottom often shows several layers of soft clay or ooze. Although in general, the shrimp schools are not located by echo sounding, they have in many instances been recorded short distances above the bottom (Fig. 1). This happens particularly during dusk and darkness when the shrimp rise from the bottom and become pelagic. In the early morning the shrimp settle again and are difficult to detect by echo sounder in the relatively deep water.

3.6.3 Mode of operation Because of the pelagic nocturnal behaviour of the shrimp, the Norwegian fishery is a daytime operation. Generally the boats start fishing early in the morning and deliver the catch that evening. However, on distant grounds a trip may last from two to three days. According to regulations it is forbidden to keep shrimp on board for more than two days, and during April to September ice must be used if the trip lasts for more than one day.

All fish are sorted from the catch by hand, the shrimp washed in sea water, and then sorted by a sieve. This is a box with horizontal bars in the bottom, spaced at 7 and 9 mm. The large shrimp are washed again and dumped in lots of about 30 lb (14 kg) into boiling sea water. When the water boils again, after a few minutes, the shrimp is ladled out and cooled in wire baskets on deck. The smaller size group are landed uncooked. The very small shrimp which passed through the 7 mm sieve are returned to the sea.

The cooked shrimp are marketed locally or exported iced in plastic containers. The smaller uncooked shrimp are peeled and either canned or frozen in consumer packages. The incidental fish catch is generally very small. In southern Norway it consists mainly of non-marketable species which are sold for mink feed. In northern Norway the fish catch at times include cod, haddock and redfish which are sold for human consumption.

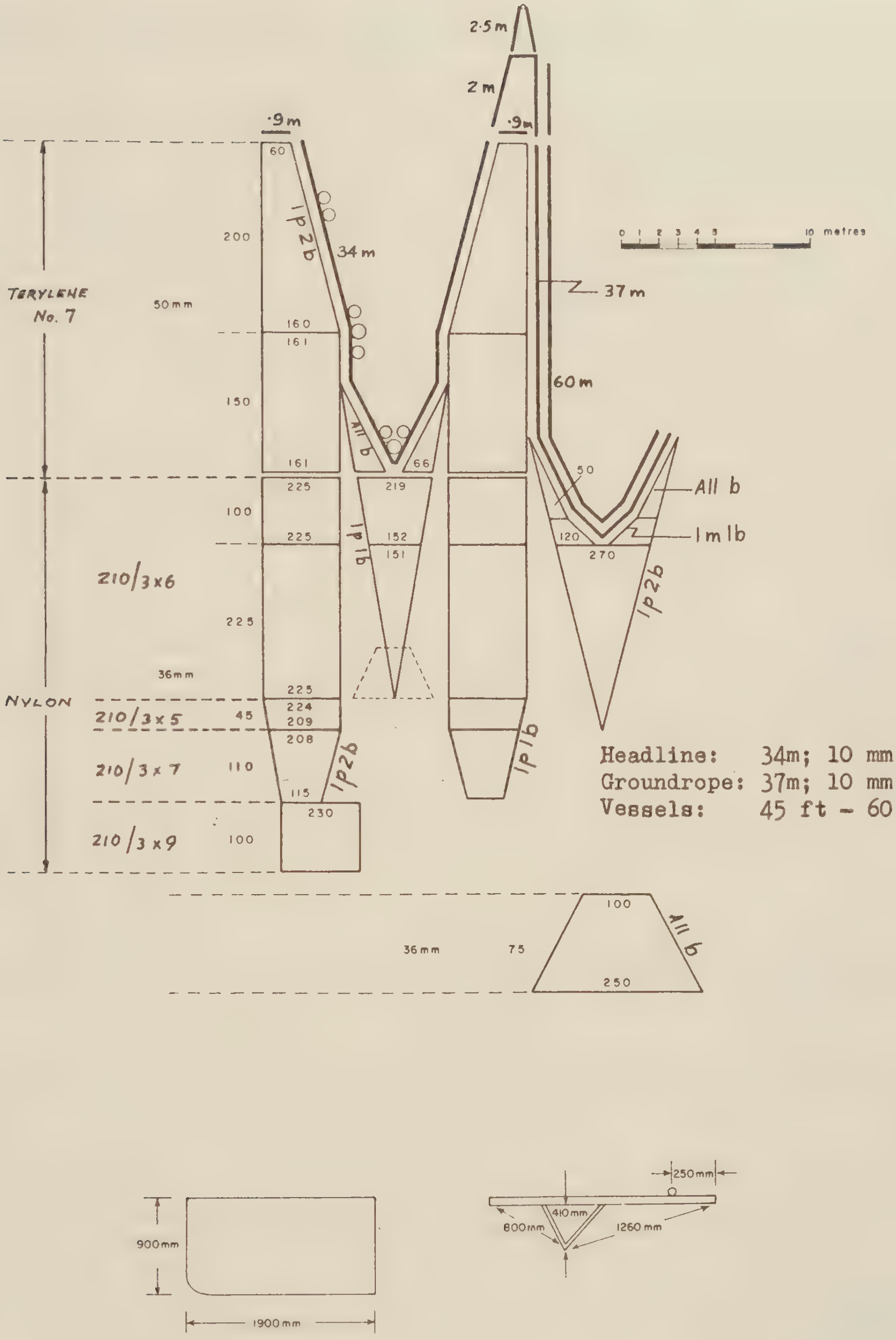
3.6.4 Fishing gear Until recently the main, or perhaps only, type of shrimp trawl was the one shown in Fig. 35. The design is of the type as commonly used in the Mediterranean for general bottom trawling for fish and shrimp. In recent years other trawl types, as illustrated in Fig. 36, have also become popular.

3.7 Mediterranean

In the Mediterranean one can hardly talk about shrimping as a separate fishery. On the other hand, shrimp is a financially important part of the catch in many trawl fisheries there. In some shallow bays, like the Gulf of Iskenderun in the eastern Mediterranean, there are relatively good shrimp grounds in shallow waters, less than 15 fm (27 m). Shrimp also makes up a sizeable part of the total catch by volume in deeper waters outside such bays.

It is a characteristic feature of Mediterranean trawling that boats of modest size, say 60 ft (18 m) with engines of only 150 to 200 hp, commonly fish at depths of 550 to 700 m (300 to 380 fm).

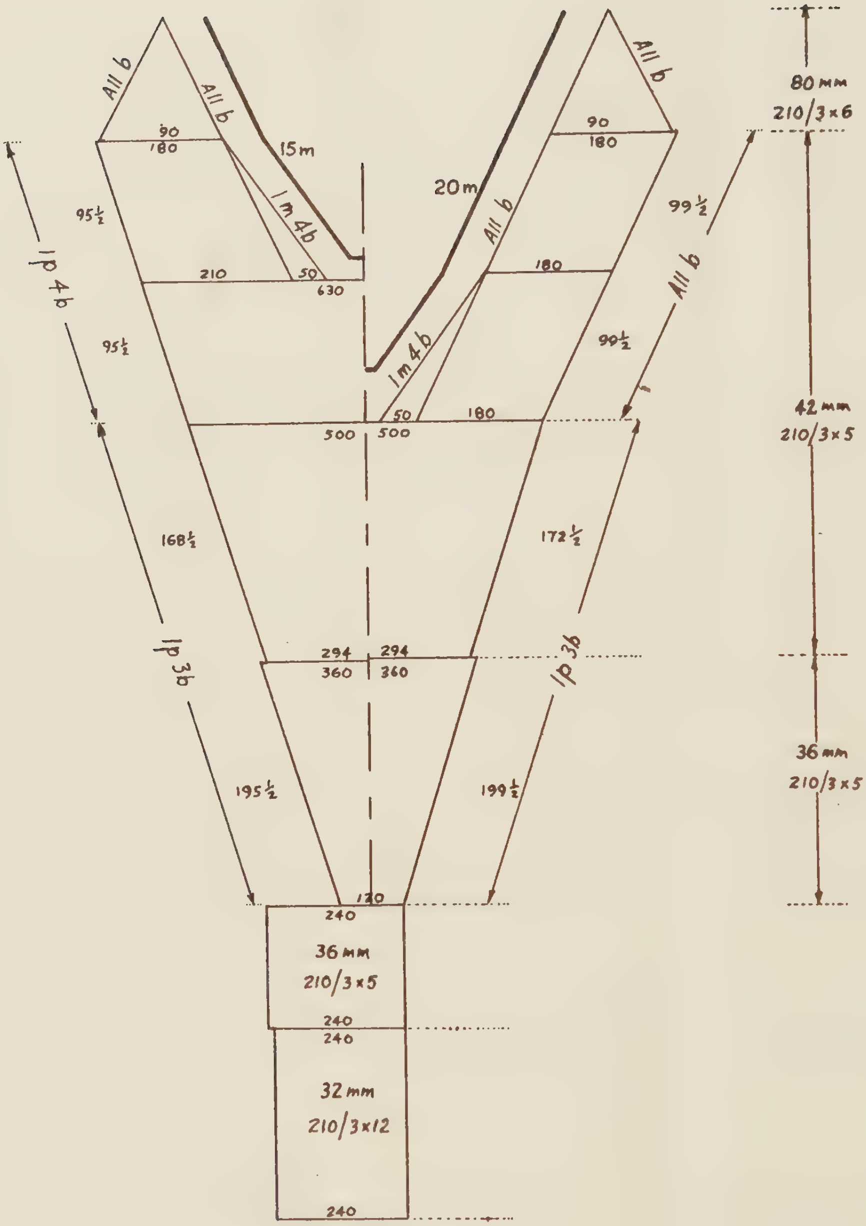
At all depths shrimp is of some economic importance in the catch and the following stratification holds approximately true for the central part of the Mediterranean : *Penaeus kerathurus* between 0 and 100 m; *Parapenaeus longirostris* between 200 and 400 m;



Headline: 34m; 10 mm dia comb rope
Groundrope: 37m; 10 mm dia comb rope
Vessels: 45 ft - 60 ft; 80-150 hp

(R. Larsen, FAO Catalogue of Fishing Gear Designs, No. 119)

Fig. 35 A 34 m Shrimp trawl as used in Denmark.



Headline: 30 m

Groundrope: 40 m

Otter boards: 85 cm x 130 cm; 135 kg

Fig. 36 Norwegian "wing" trawl.

Aristaeomorpha foliacea (Red shrimp) and Aristeus antennatus between 400 and 700 m (Bourgois and Farina in FAO/UN, 1961).

Trawling is conducted in deep water for two reasons; one is higher catch rates by weight (fish and shrimp); the other is the presence of the two last named shrimp species which form an important but not dominant part of the catch by value.

Virtually throughout the Mediterranean the same gear is used, i.e. the net illustrated in Fig. 35, in the chapter on Norwegian shrimping. This net is used in Scandinavia specifically as a shrimp trawl, while in the Mediterranean it is used as a general purpose trawl, usually with very long sweeplines, i.e. 80 to 120 fm (145 to 220 m) combination rope (25 to 32 mm diameter) between the net wings and the otter boards. These sweeplines have a rather modest angle of attack, normally less than 9° (Scharfe, 1959), allowing fish and perhaps also shrimp sufficient time to be herded into the path of the oncoming net. Contrary to common belief, such long sweeplines account for only a very modest part of the total towing resistance of the gear, i.e. about 8 percent at a towing speed of about 3 knots. The last 4 to 5 fm of the sweeplines, nearest to the trawl wing, are wrapped with coir rope to form 'mudropes' of about 50 to 75 mm (2 to 3 in) diameter. The sweeplines and the mudropes are believed to greatly increase the catching power of the trawl gear by herding the fish into the net.

The otter boards used are relatively small for 120 to 150 hp. Boards of 1.60 by 0.92 m, equalling 1.5 sq m, are commonly used. The otter boards (Fig. 37) are normally fitted with broad mud shoes, especially for deep water trawling where semi-liquid muddy ooze is often encountered. With an angle of attack of about 20 to 30°, these otter boards spread about 70 to 80 m at 3 knots towing speed, with 200 m sweeplines and very small-meshed net of approximately 30 m headline/35 m footrope (Fig. 38). The total pull in the towing blocks might then be 1,300 to 1,400 kg; the warps and otter boards accounting for 24 percent (310 to 340 kg), the sweeplines 8 percent (110 kg) and the net 68 percent (890 to 950 kg),(Scharfe, 1959).

3.8 Western Europe

The shrimp fishery of Western Europe yields a significant total catch of over 50,000 t a year. The main species taken are Crangon crangon and Pandalus borealis, although several other species are also taken in smaller quantities.

A considerable variety of gear is used, ranging from fykenets and stownets in estuarine waters to beam trawls and otter trawls of several different types. Fig. 39 shows a typical French otter trawl used by small shrimp trawlers.

The most notable feature of Western European shrimp trawling is the rather recent trend to double-rig beam trawling, as illustrated in Fig. 40. Many of the important shrimp grounds in this region are in estuarine and inshore waters, with very strong tidal currents, and this is no doubt the main reason for using beam trawls. The advantages claimed (Verhoest and Maton, 1964) for these over otter trawls under these conditions are that they are less affected by the current: (i) the influence of tidal currents is much less on a beam trawl than on an otter trawl since the opening is fixed regardless of speed through the water, whereas otter boards lose their effectiveness when speed through the water is low; (ii) the length of warp has much less influence on the operation of a beam trawl than on an otter trawl; (iii) the opening of the otter trawl changes during course alterations and when the bottom consistency changes, whereas the beam trawl opening is fixed.

The beam trawl sizes range up to 10 m (beam) and the vessels are generally 12 to 20 m in length and of 40 to 125 hp.

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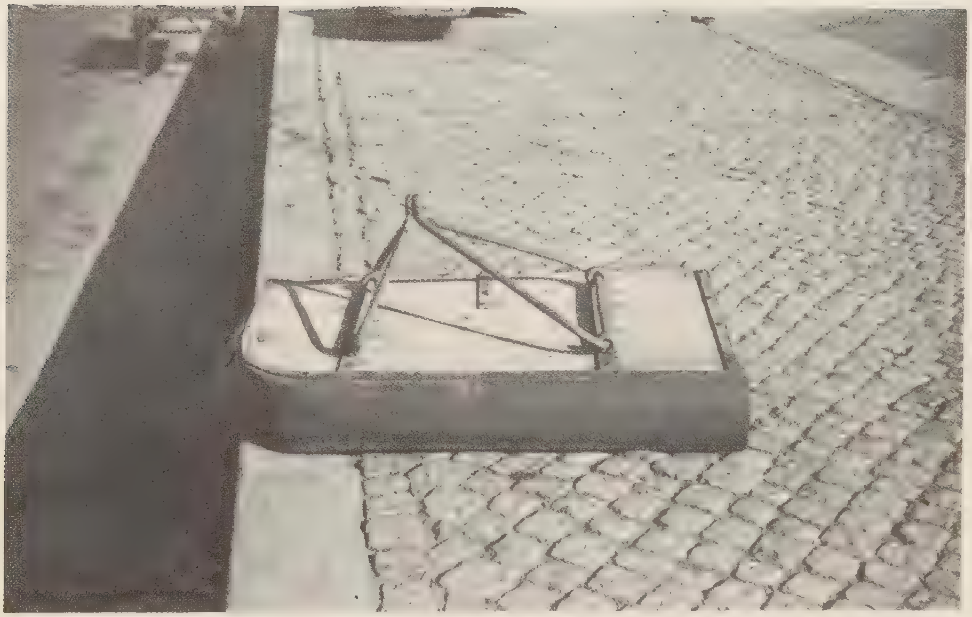


Fig. 37 A typical Mediterranean trawl board with broad mud ski and of light construction.

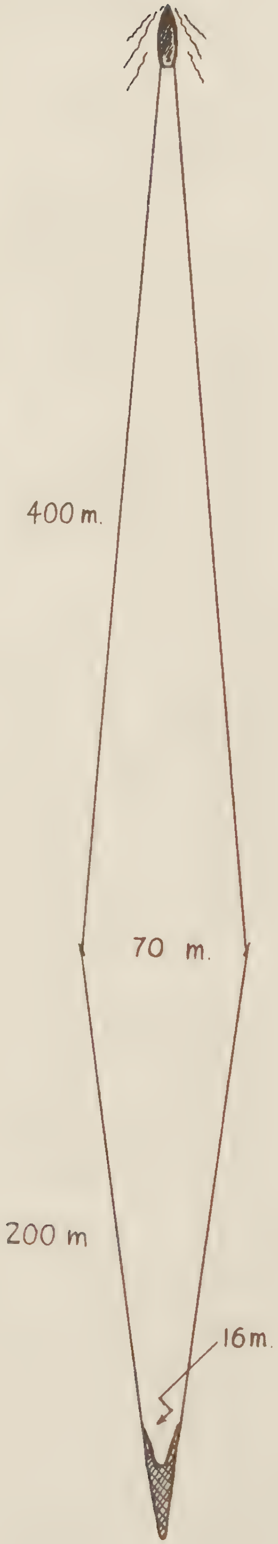
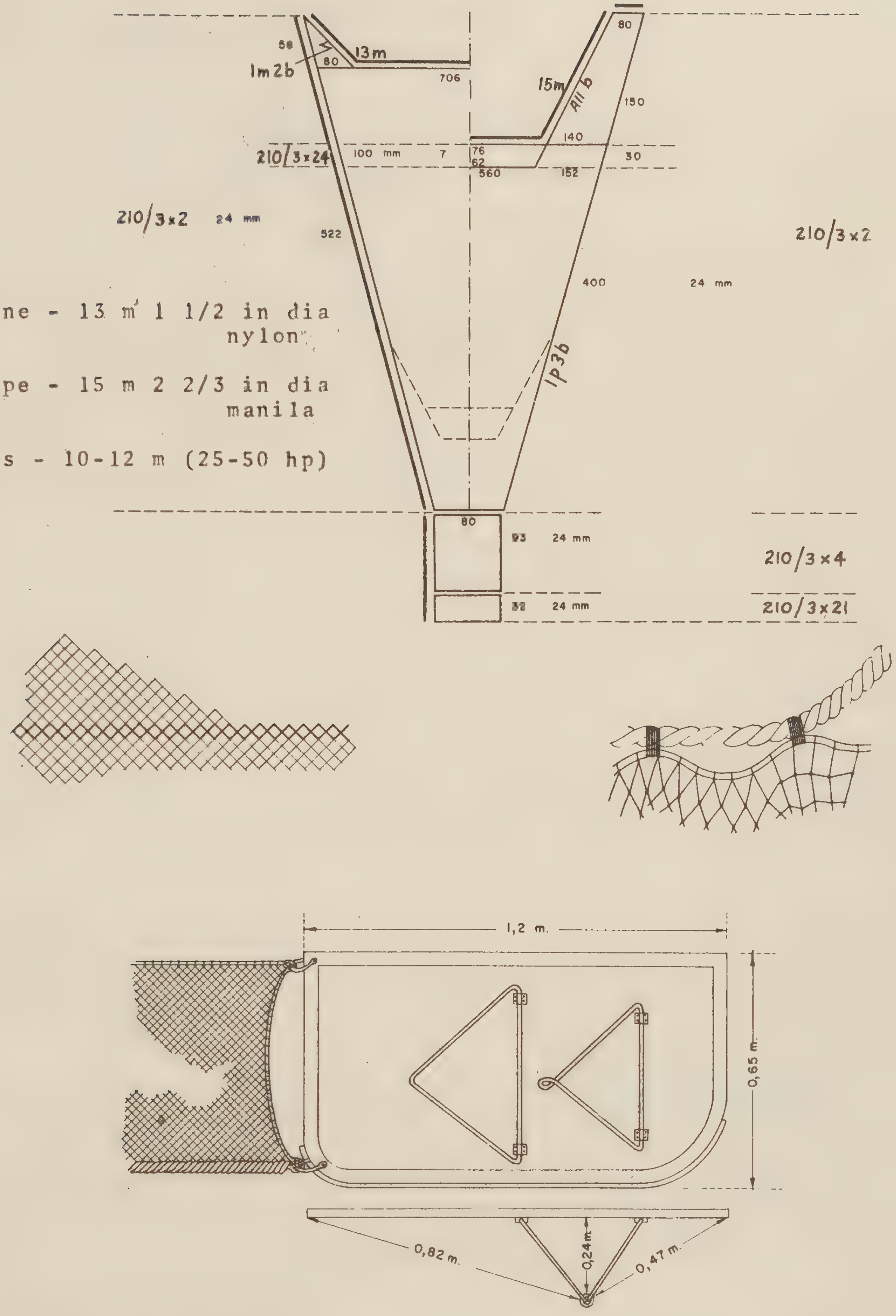


Fig. 38 Mediterranean trawl gear drawn to scale : Vessel 18 m, engine 130 hp, warps 400 m, sweeplines 200 m, spread between otter boards 70 m and between wingtips of trawl 16 m.

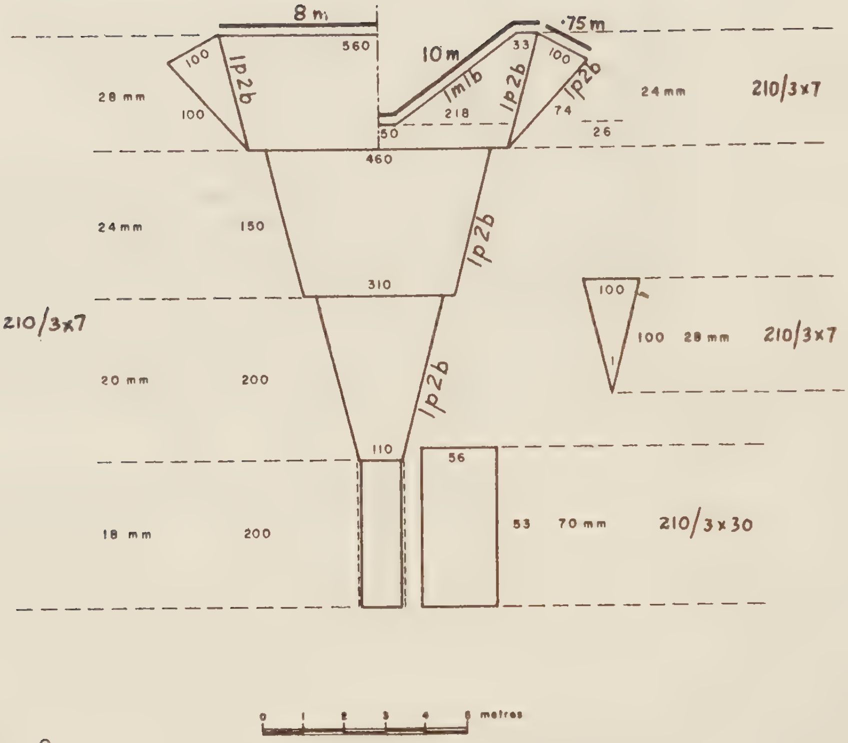


Headline - 13 m 1 1/2 in dia nylon

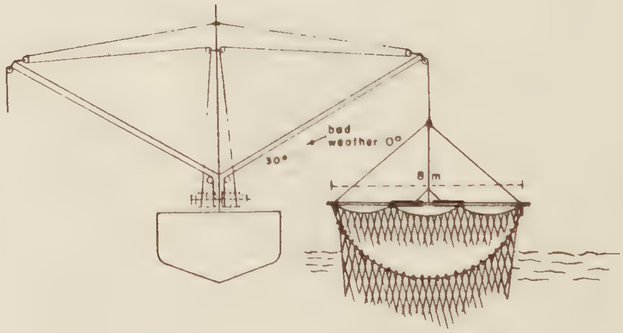
Footrope - 15 m 2 2/3 in dia manila

Vessels - 10-12 m (25-50 hp)

Fig. 39 French shrimp trawl for small vessels.



Headline: 8 m
Footrope: 10 m
Vessels: 16-18 m (80-120 hp)



(FAO Catalogue of Fishing
Gear Designs, No. 121)

Fig. 40 Dutch Double-Rig Beam Trawl.

3.9 Japan

The greatest variety of shrimp catching gear and techniques is probably found in Japan. The main methods are trawling and Danish seining; other methods are bottom driftnetting, purse seining, fishing with dip nets, with brushwood shelters and various types of traps.

3.9.1 Trawling In the Yellow Sea and East China Sea there is a considerable trawl fishery for Penaeus orientalis, mainly in depths of 90 to 180 m. The shrimp is caught both on the bottom and in midwater. Yellow croaker is also a prominent species in this fishery (Hirano and Noda, 1964).

Side trawlers of 350 to 500 gross tonnage and 700 to 850 hp use four-seam type nets made of black polyethylene knotless netting. Figs. 41 and 42 show a typical net of 44 m headline and 55 m footrope which can be fished either on the bottom or in midwater. Bull trawlers of 70 to 130 gross tonnage, 200 to 300 hp, also operate on these grounds with nets having extremely long wings (Figs. 43, 44).

In 1959/60 echo sounding techniques revealed that the shrimp schooled well off the bottom during a part of the year. Some boats then started trawling in midwater, and by 1964 some 200 of the above fishing units were regularly engaged for about five months of the year in midwater trawling for Penaeus orientalis and yellow croaker, both with otter trawls and bull trawls.

Many of these ships were equipped with high frequency echo sounders (100 kc/s or 200 kc/s) or dual frequency echo sounders of 28 to 50 kc/s and 100 to 200 kc/s for detecting the shrimp and croaker schools (Figs. 45, 46).

The nets were aimed at the right fishing depth by the use of headline mounted transducers linked to the shipboard echo sounder recorder with electrical cable (Fig. 47) or wireless acoustic telemetry (Fig. 49). The shrimp schools were often found about 10 m above the bottom, but sometimes as high as 30 to 40 m.

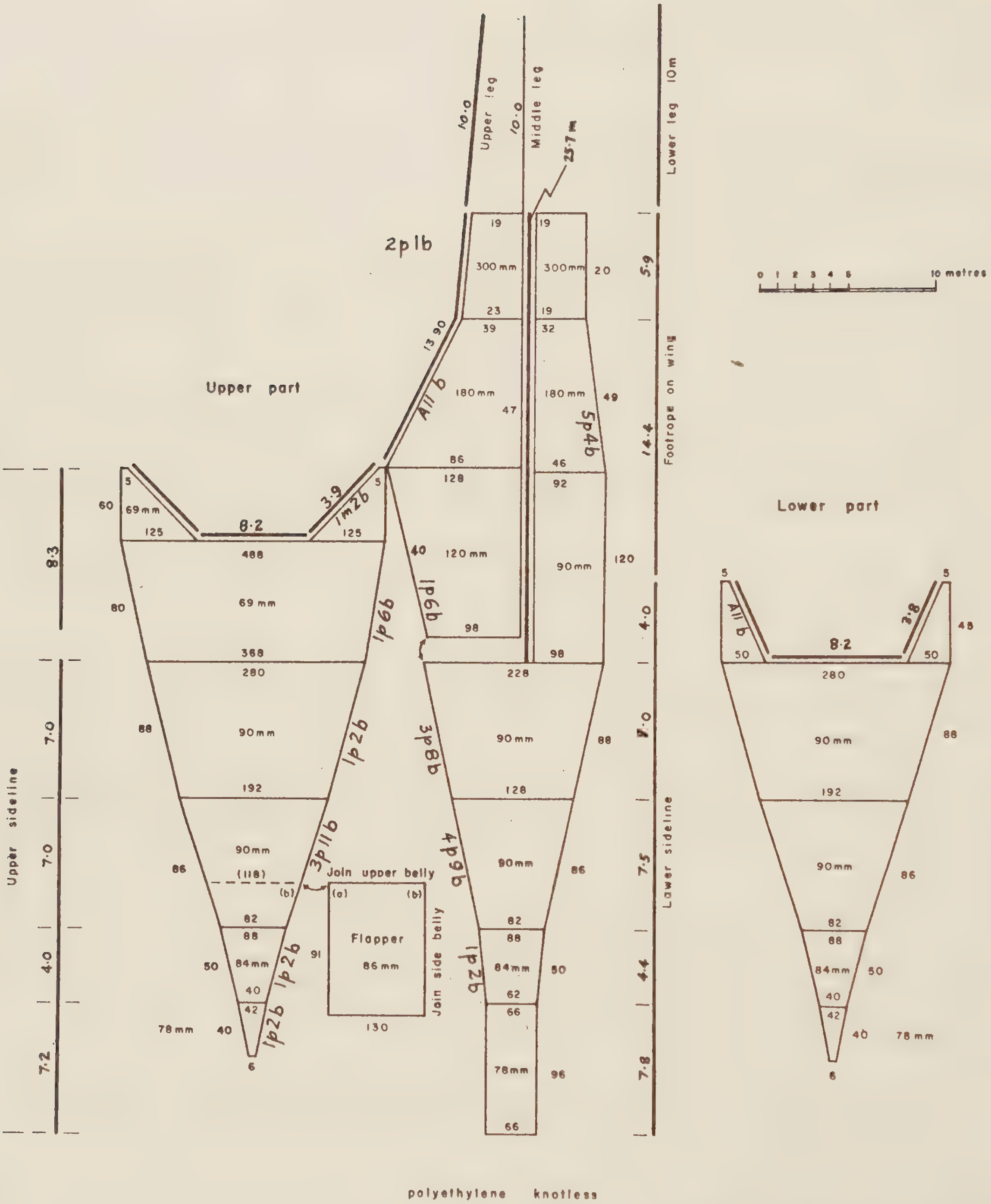
When the nets need to be lowered or raised slightly to intercept a school, this is achieved by slowing or increasing the speed. The curved (Suberkrub) otter boards (Fig. 42) are so balanced as to develop a lift when the speed is increased. If a very considerable depth change is needed, it is necessary to haul or veer the warps as well.

The netsonde and the curved Suberkrub otter boards were discussed at the first FAO Gear Congress in Hamburg in 1957 and described in Modern Fishing Gear of the World, 1959 (Scharfe, 1959; Suberkrub, 1959; Woodgate, 1959). The Japanese were the first to adopt aimed midwater trawling in commercial fishing (for shrimp in the Yellow Sea and East China Sea) by combining these two features. Years later it was introduced in herring midwater trawling in Northern Europe.

After 1964 shrimp was not found to any great extent in midwater in the Yellow Sea, perhaps due to a change in oceanographic conditions, and midwater shrimp trawling was therefore largely discontinued there for the time being.

The same type of high curved otter boards, and the headline transducer equipment, with or without cable (Figs. 47, 49), are also widely used in Japanese bottom trawling for fish as well as shrimp. The headline transducer gives a continuous indication of the opening-height of the net, which often is of critical importance (Fig. 48) and always a useful tell-tale sign.

In very shallow water, say inside 10 fm (18 m), bull trawling may have inherent advantages as compared to single-rig otter trawling. Under these conditions, otter trawl warps must be relatively very long in relation to water depths, and consequently



(FAO Catalogue of Fishing Gear Designs, No.124)

Fig. 41 Midwater shrimp trawl for 850 hp Otter Trawler.

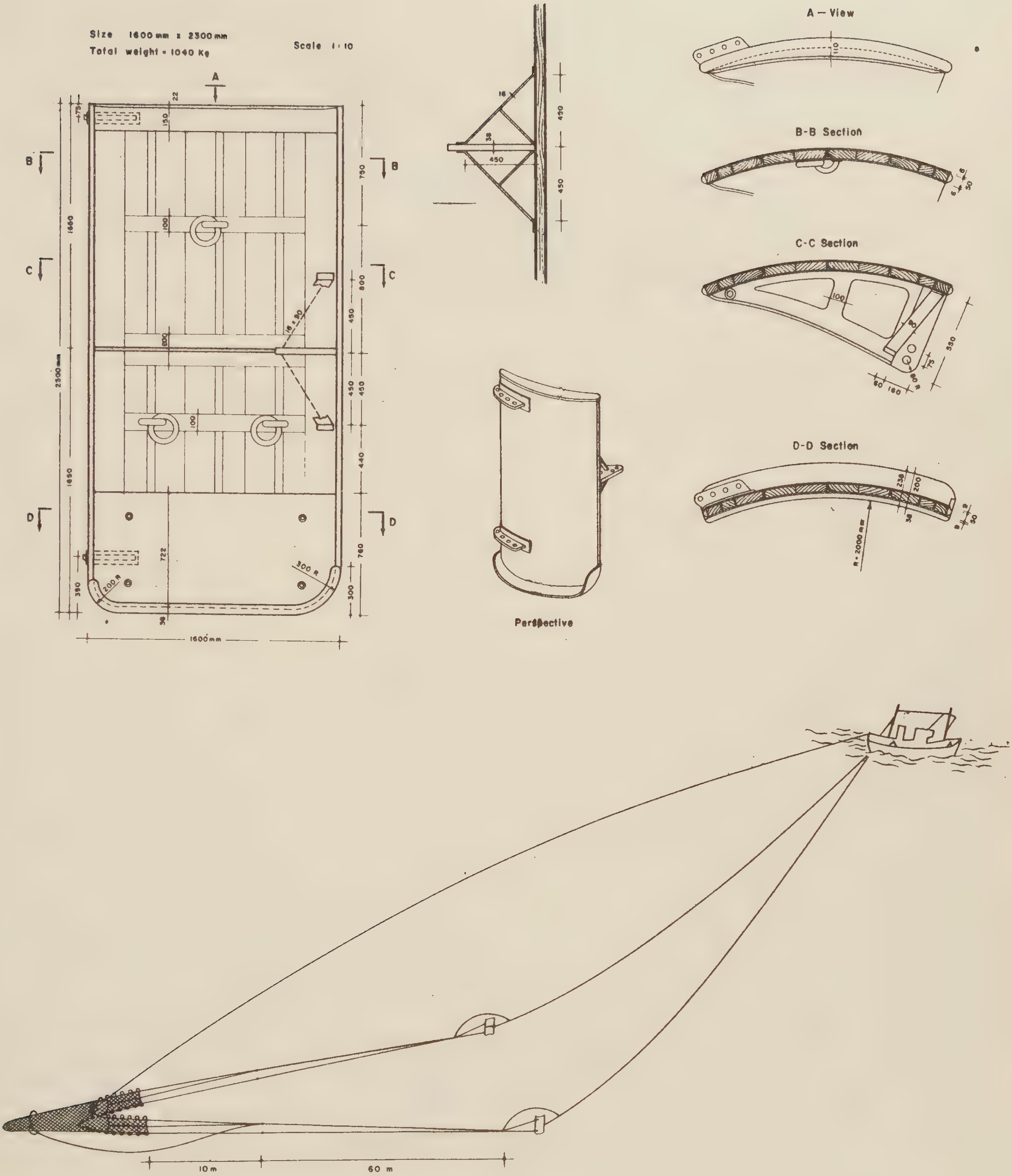
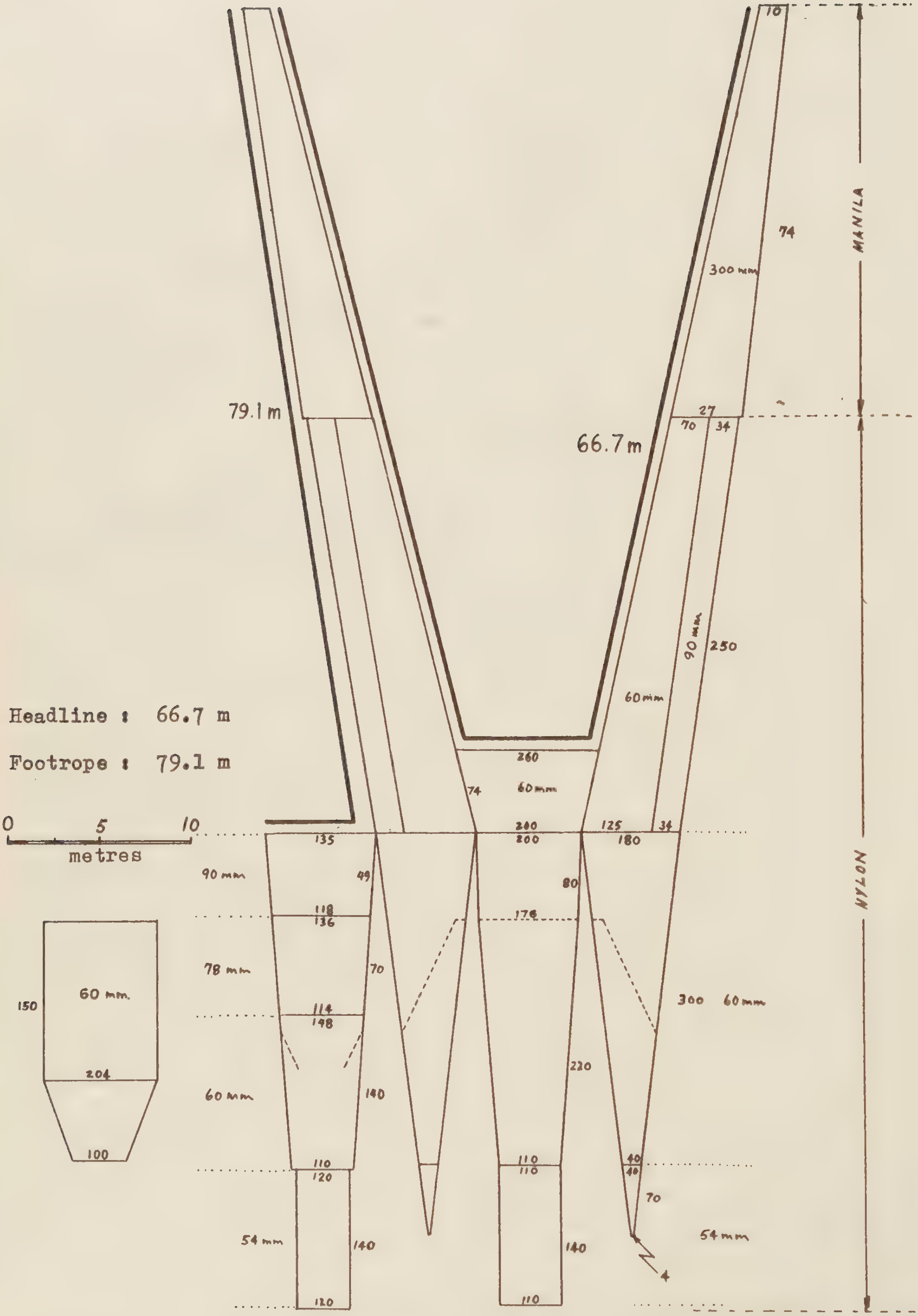


Fig. 42 Upper: Construction details of curved high otter boards used with Japanese midwater and bottom trawls.

Lower: Schematic description of single-boat midwater trawling using a netsonde.



Headline : 66.7 m

Footrope : 79.1 m

Fig. 43 Japanese bull trawl used by two 75 t 250 hp vessels for shrimp (Penaeus orientalis) and yellow croaker in the Yellow Sea.

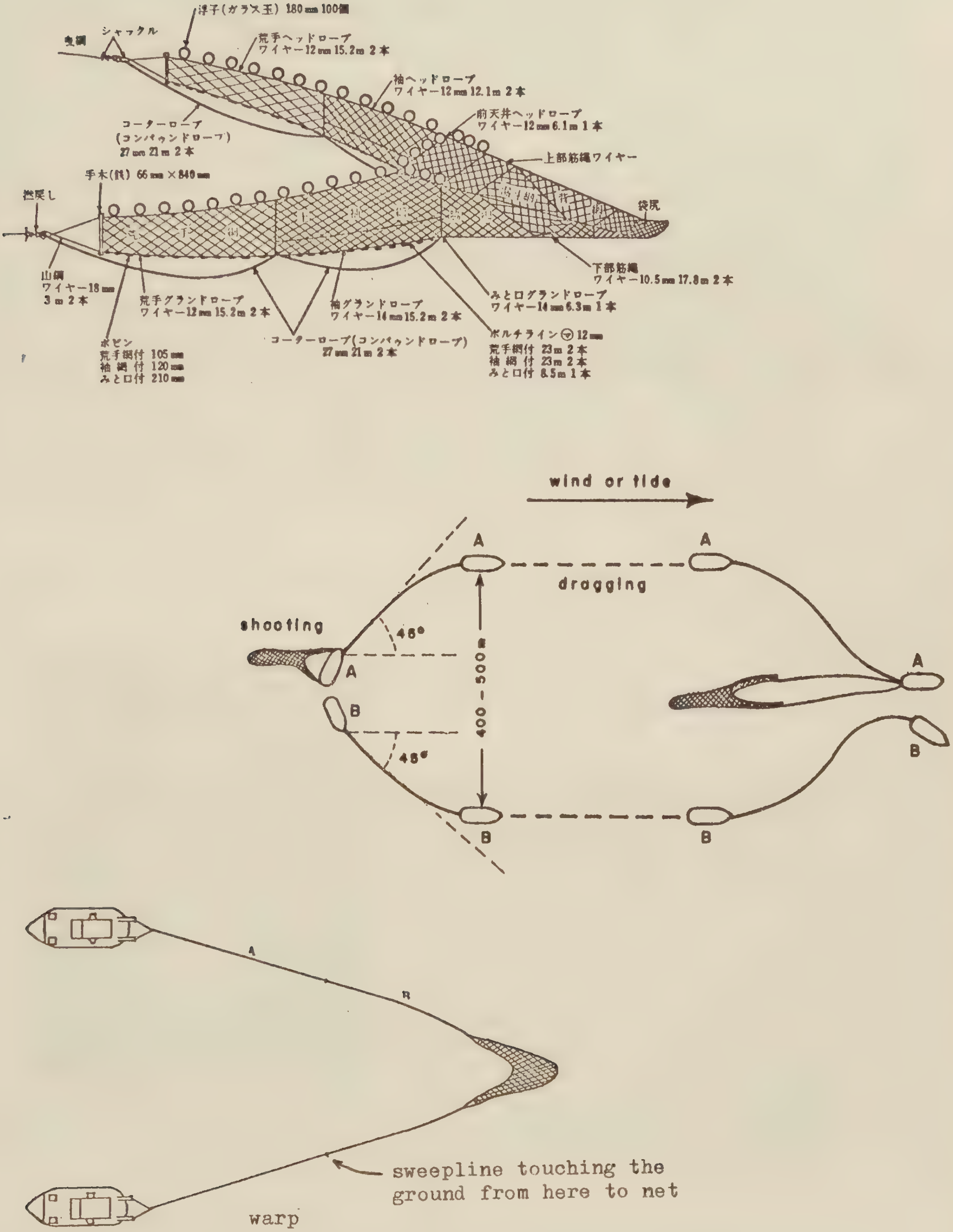


Fig. 44 Japanese bull trawling gear.

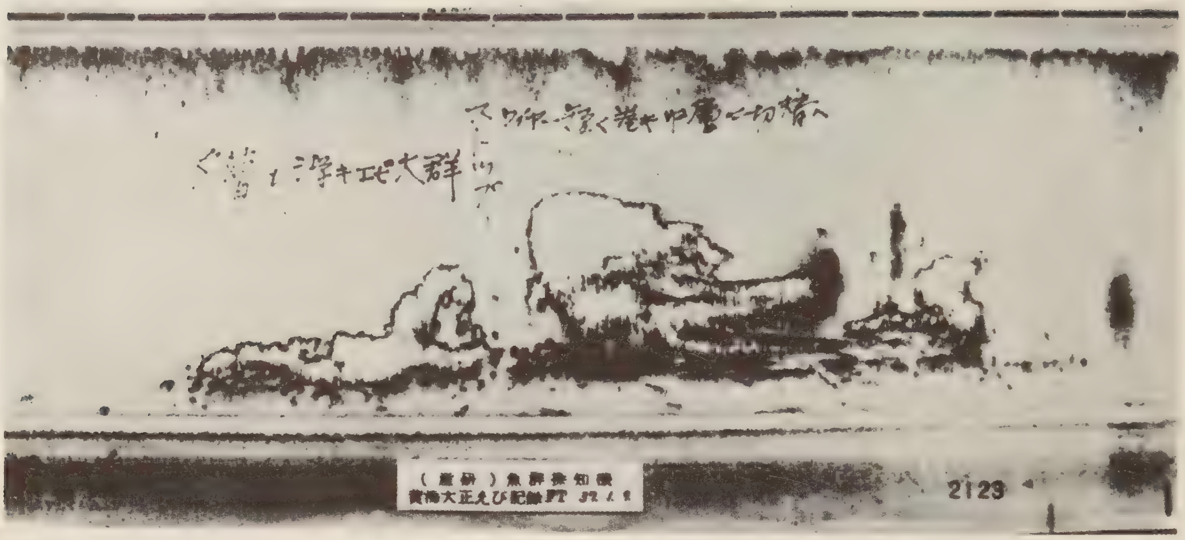
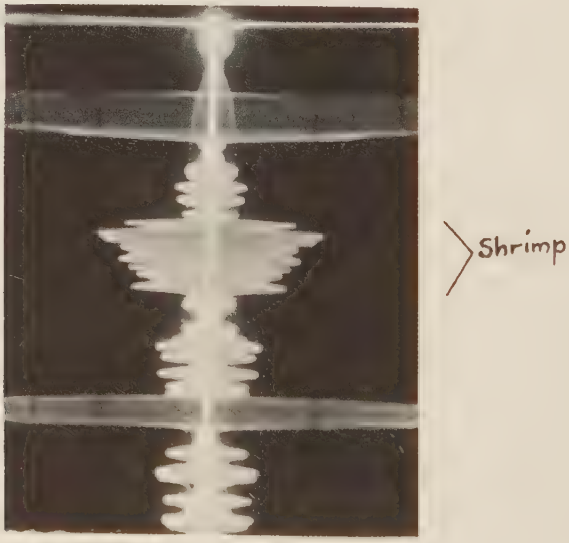


Fig. 45 Echo chart showing a large school of Penaeus orientalis that rose from the bottom of the Yellow Sea at dusk on January 9, 1962. Depth of water 75 m. The highest layer of the school 44 m and the lowest layer 7 m above the bottom.



Fig, 46 Traces of a school of the shrimp entering the net as seen on the screen of the cathode ray tube. Height of the net mouth 7.5 m.

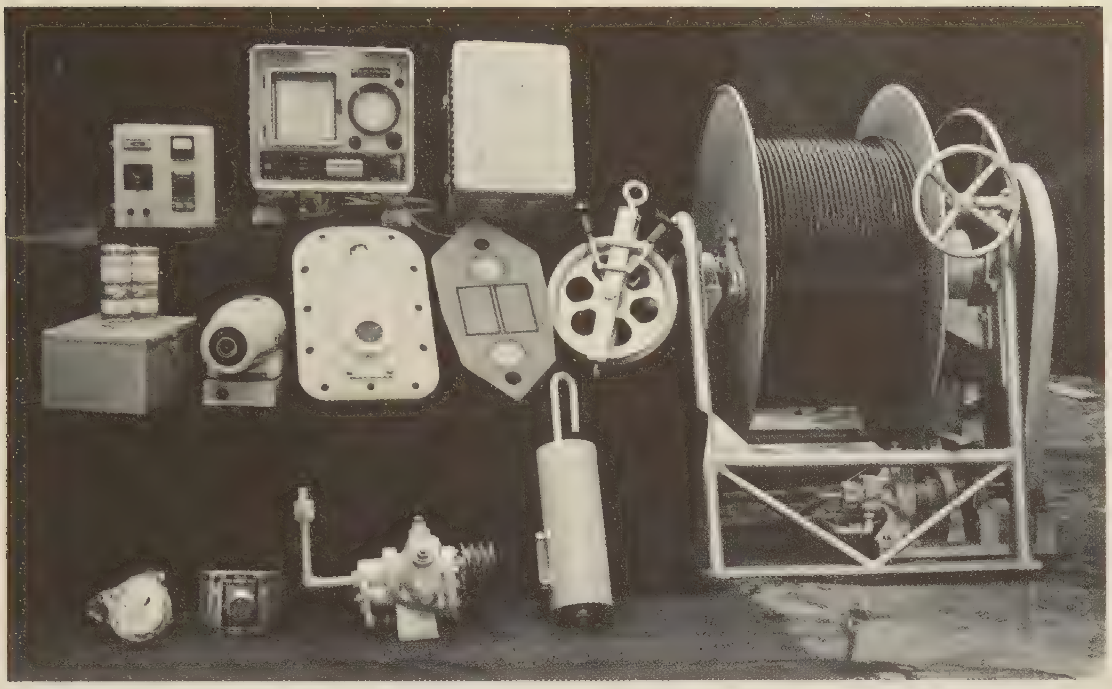


Fig. 47 Component parts of a complete headline sounding unit (Sanken 'NET VISION' Model NV 4-500). Switchboard, main receiver unit housing the paper recorder, cathode ray tube, and amplifier and impulse generator are shown in the upper row. A spares box, recorder paper containers, converter, headline transducer, shimp's transducer, netszonde, and cable pulley are shown in the centre row. Oil pressure gauge, flow control valve, hydraulic pump and oil tank are shown below. Cable reel with hydraulic motor and brake are shown to the right.

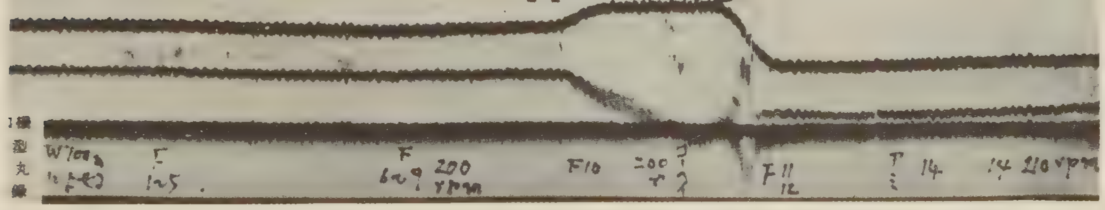


Fig. 48 Traces of net towed a little above the bottom with a propeller at 200 to 210 rpm. Depth of water : 61m. At A the net slows and opens up, the footrope sinking to the bottom. At B towing is resumed and net travels closer to the bottom.

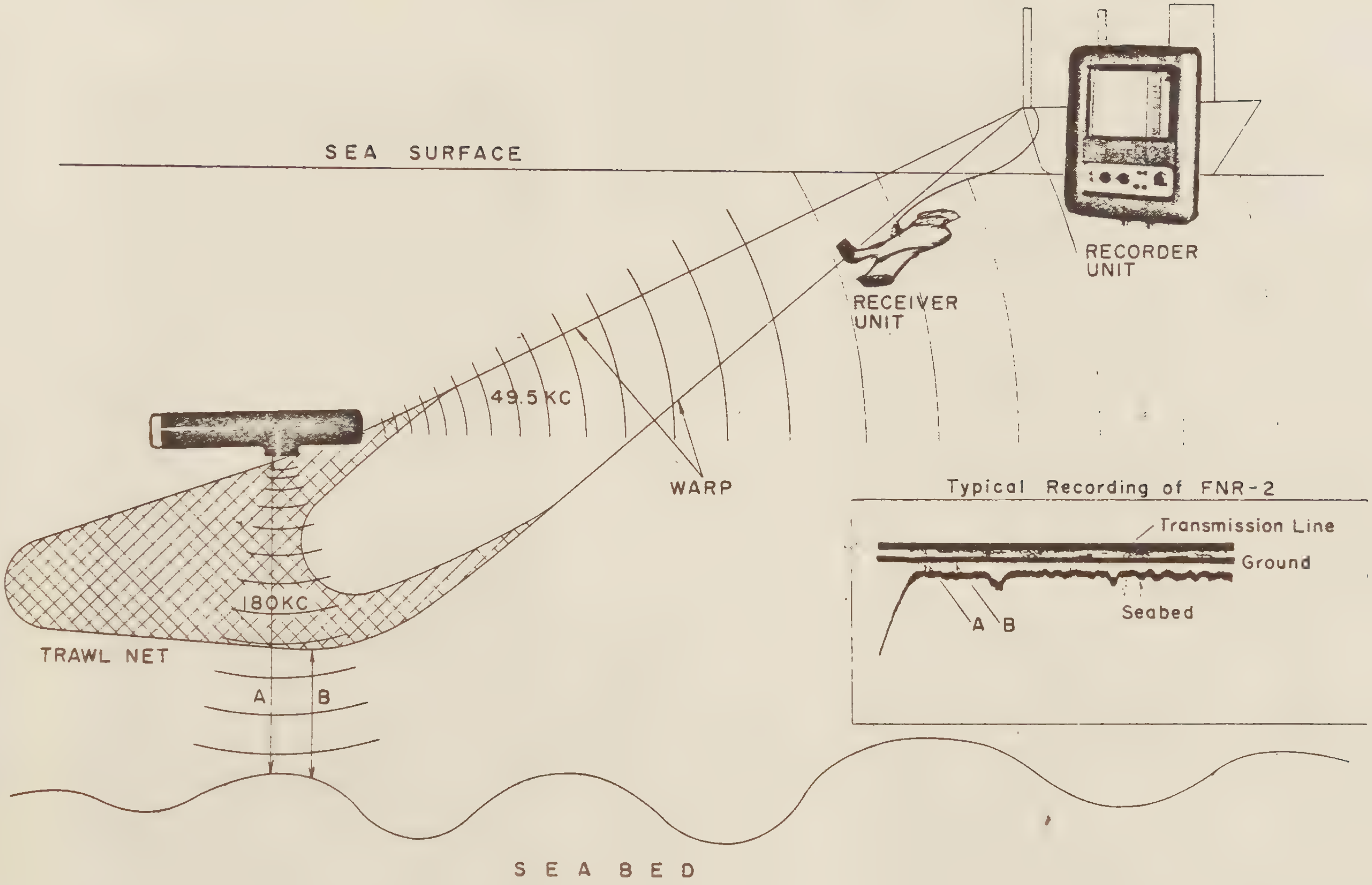


Fig. 49 Furuno "Net Recorder" wireless type headline transducer.

they may disturb the bottom in front of the otter boards, tending to drive the fish and shrimp out of the path of the net. When otter trawling in shallow water, the propeller wake may also be felt several fathoms down; propeller noise may also possibly be a disturbing factor. In the latter instance it is noteworthy that five-bladed propellers are popular in Gulf of Mexico shrimpers and believed to be 'smoother'. These matters are worth further consideration, particularly since in the tropics the most productive shrimp grounds are often found very close inshore in 1 to 10 fm depth.

Small trawl boats of 1 to 10 gross tonnage operate in the Inland Sea and in shallow coastal waters for Penaeus japonicus, Penaeus monodon, Metapenaeopsis barbata, M. acclivis, M. lamellata and Trachypenaeus curvirostris, with small otter trawls, bull trawls, beam trawls and dredges (Figs. 50, 51, 52).

3.9.2 Danish seining Danish seiners of 30 to 65 gross tonnage and also trawlers of the same size fish for shrimp in the Japan Sea, Okhotsk Sea and Bering Sea for Pandalus hypsinotus, P. borealis, P. goniurus, P. kessleri, P. nipponensis and Metapenaeopsis lamellata. Fig. 53 shows a typical Danish seine.

In the Bering Sea fleet operations, several Danish seiners, bull trawlers or otter trawlers supply a shrimp cannery ship or a freezer ship; fishing operations last from April to September, i.e. when weather conditions are relatively favourable. The boats fish mainly in depths of 100 to 300 m (Tominaga, 1961).

Small Danish seiners, of 3 to 10 gross tonnage, fish in the Inland Sea and in shallow coastal waters for the same species as the small otter and beam trawlers mentioned above (Section 3.9.1). In Danish seining, a flag buoy is first thrown in the sea, then the boat streams out the first warp as shown in Fig. 54. When about two-thirds of the first rope has been shot, the boat makes a rounded turn, shooting the rest of the first rope and the net, and when about one-third of the second rope has been shot, the boat makes another rounded turn and heads for the buoy, which is taken on board. The boat now tows very slowly while the ropes are gradually coming together herding shrimp and fish into the path of the net. Then the speed is increased and the net hauled more rapidly, scooping up the catch. An advantage of this fishing method is that a very large net can be operated by a small boat of low power. (See the chart of comparative shrimp trawl sizes). Also a relatively large area can be swept in a given time. Furthermore, this method makes it possible to sweep rather effectively small areas of clear ground in among rough spots, where it may be difficult or impossible to maintain a trawling course.

3.9.3 Bottom driftnetting Small boats of 1 to 5 gross tonnage fish with bottom driftnets in coastal bays for Penaeus japonicus. The driftnets (Fig.55) have a turned up lower edge which is attached loosely at intervals to the vertical netting, about one-fifth of the way up, forming pockets in which the shrimp collect. The nets are about 7 m long and 2 m high, the turn-up making a 40 cm deep pocket. When shrimp at the bottom touch the net they jump up, hit the net and fall into the pocket. These nets are used for taking both shrimp and crab along the coast of Honshu, mainly in the spring and summer. The Japanese name is 'genshiki ami'. Usually about eight nets in a string are fished by each boat; they are set obliquely to the current and left drifting. A buoy is attached to one end of the fleet of nets, while the other end is attached to the boat. During the drifting, the angle of net to the current gradually increases, since the boat drifts faster than the float. When the nets have come to lie at right angles to the current, they are hauled and the shrimp removed.

3.9.4 Shrimp purse seining Boats of 5 to 15 gross tonnage fish in coastal waters, including Tokyo Bay, in depths of 10 to 30 m for Metapenaeus joyneri. Fig. 56 shows a net which is used both for catching shrimp and sardines. The seine is 243 m (132 fm) long on the floatline and 297 m (162 fm) on the leadline.

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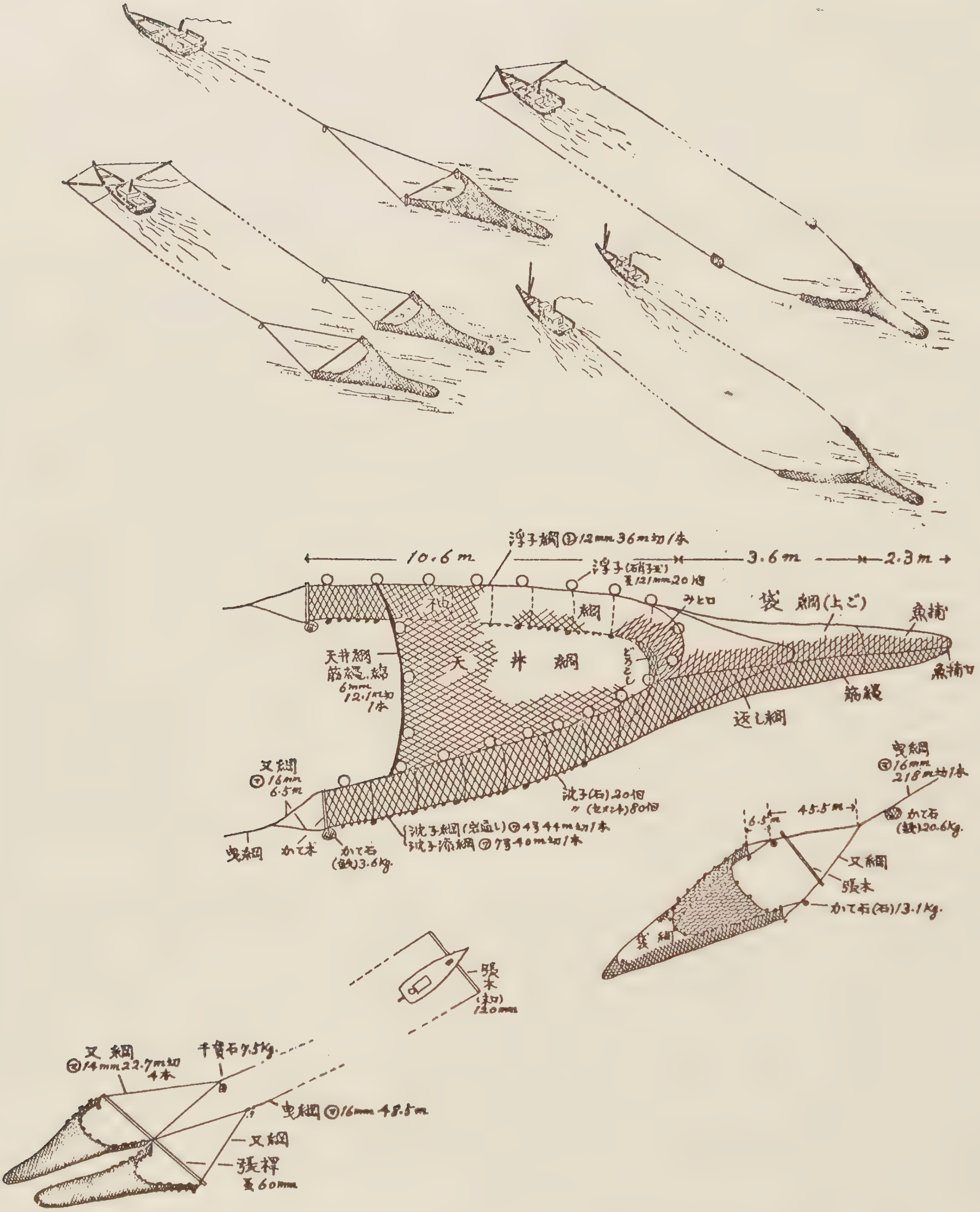
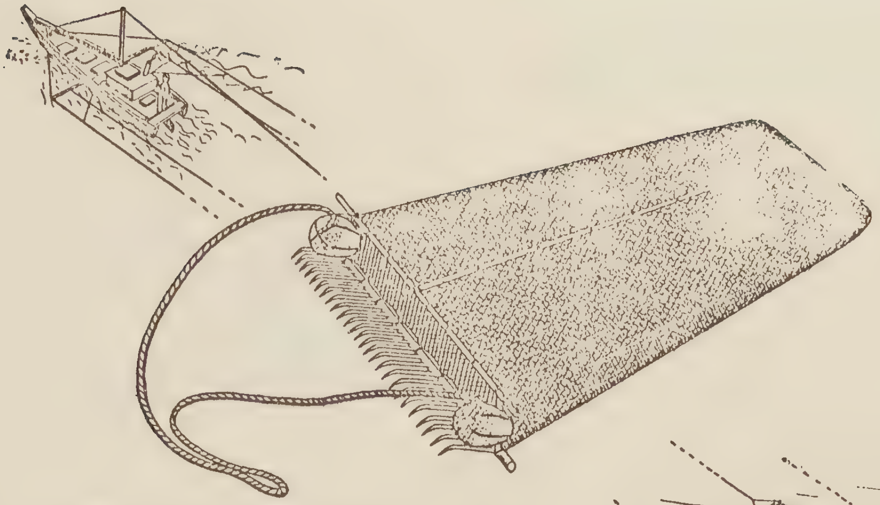


Fig. 50 Small shrimp trawls used in Japan by boats of 1 to 10 gross tonnage and up to 20 hp, fishing in Seto Inland Sea, Ariake Bay and other coastal waters chiefly for shrimp, but also conger eel, flatfish, octopus and crab; operated mainly at night.



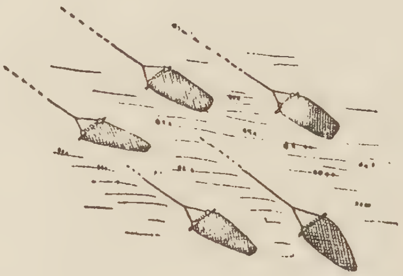


Fig.51 Dredge 'Keta Ami' for shrimp, crab, clam, flatfish, sea-cucumber, etc. used in Japanese coastal waters. Each boat tows 2 to 3 dredges, Iron or wooden frame is 1 - 1½ m wide with 20-30 cm vertical opening; net bag 2-3 m long. The frame has a number of teeth which dig into the ground. Also 2 iron or stone sinkers are attached.

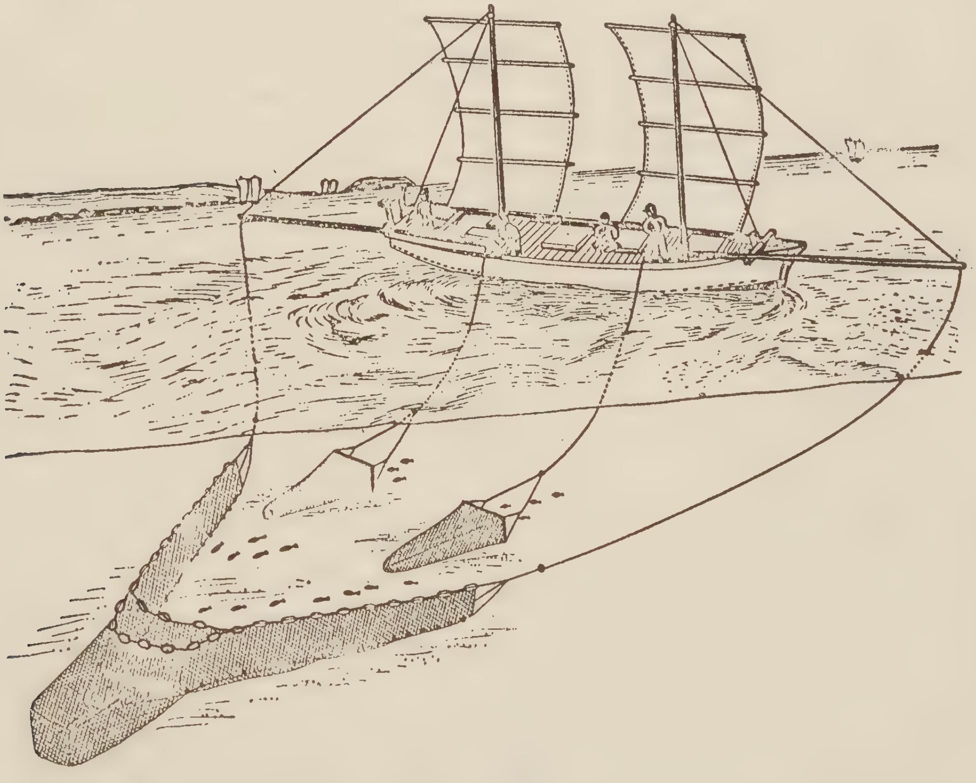


Fig. 52 Shrimp trawl 'Utase Ami' used by sailing boats sailing sideways as shown in the drawing, in coastal waters for catching shrimp, crab, flatfish, etc.

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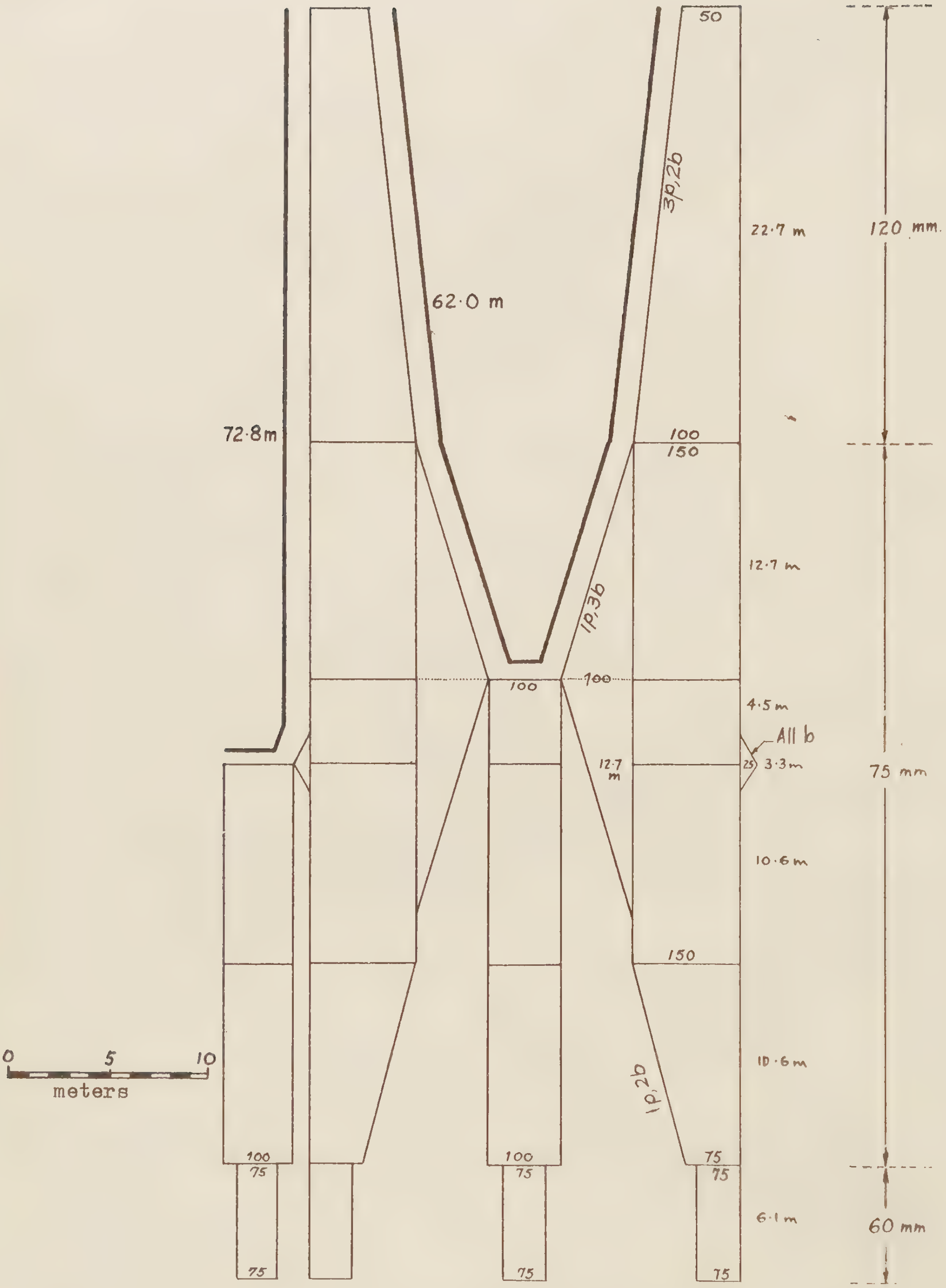
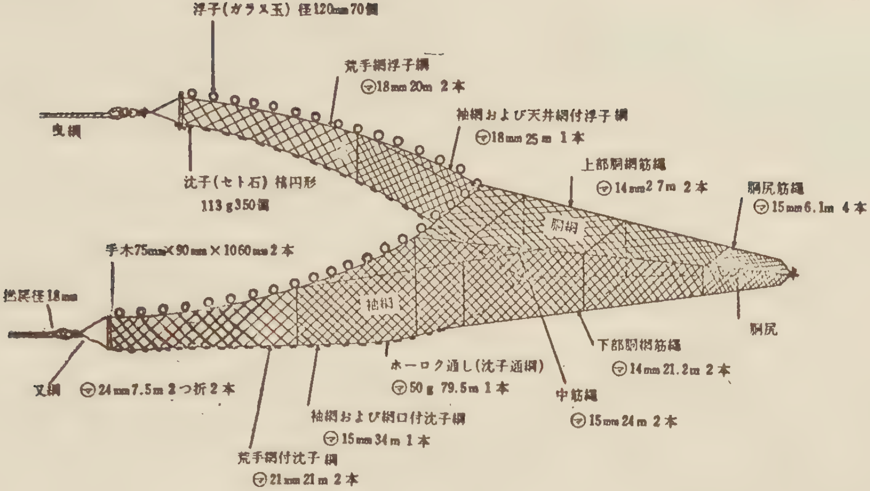


Headline: 62.0 m

Footrope: 72.8 m

Fig. 53 Danish seine for shrimp and fish used by vessels of 40 to 65 gross tonnage and 250 hp engine.

Japanese Danish seine net
for shrimp and fish



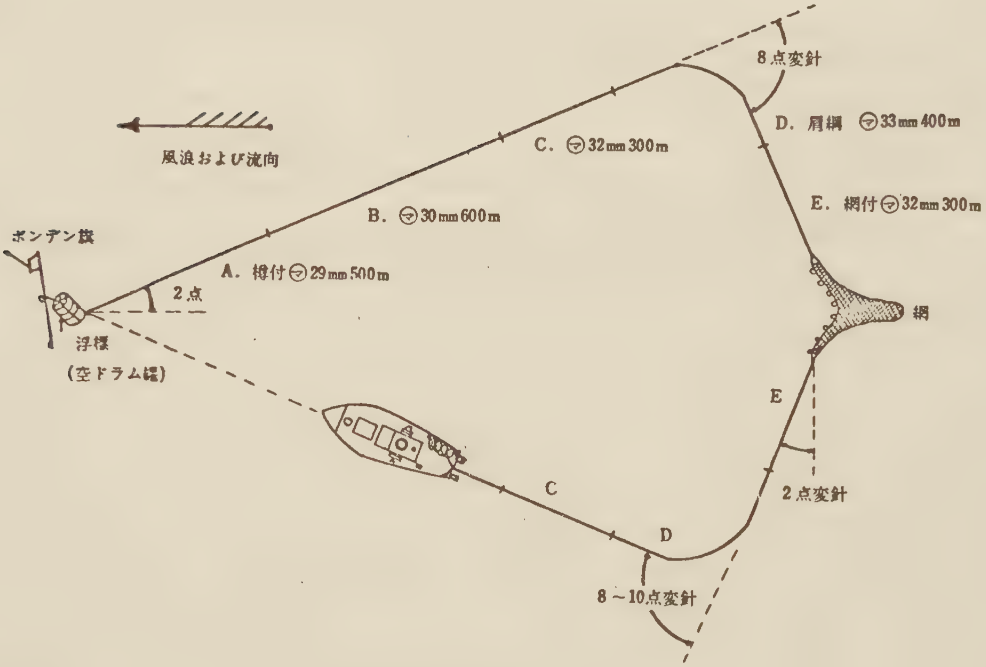
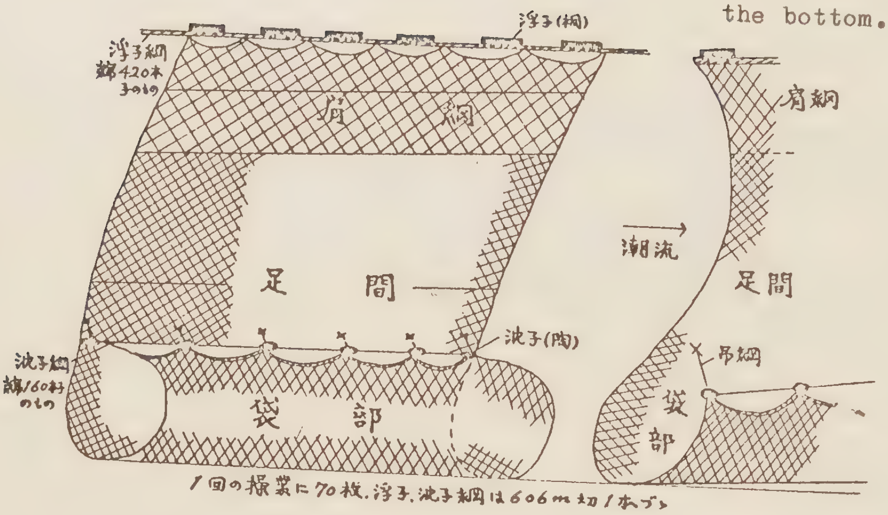


Fig. 54 Explains the operation of a Danish seine. The boat first sets out a flag buoy (left) and then steams out the seine warp ropes which are of graduated diameter (29, 30, 32, 33, 32 mm); total length 2,100 m (7,000 ft.). Next the net is shot and then the second warp. After picking up the buoy the boat advances very slowly while the warps gradually come together, sweeping shrimp and fish into the path of the net which then is towed faster to scoop up the catch.

Fig.55
Japanese shrimp bottom driftnet (Genshiki Ami) with pocket along the bottom.



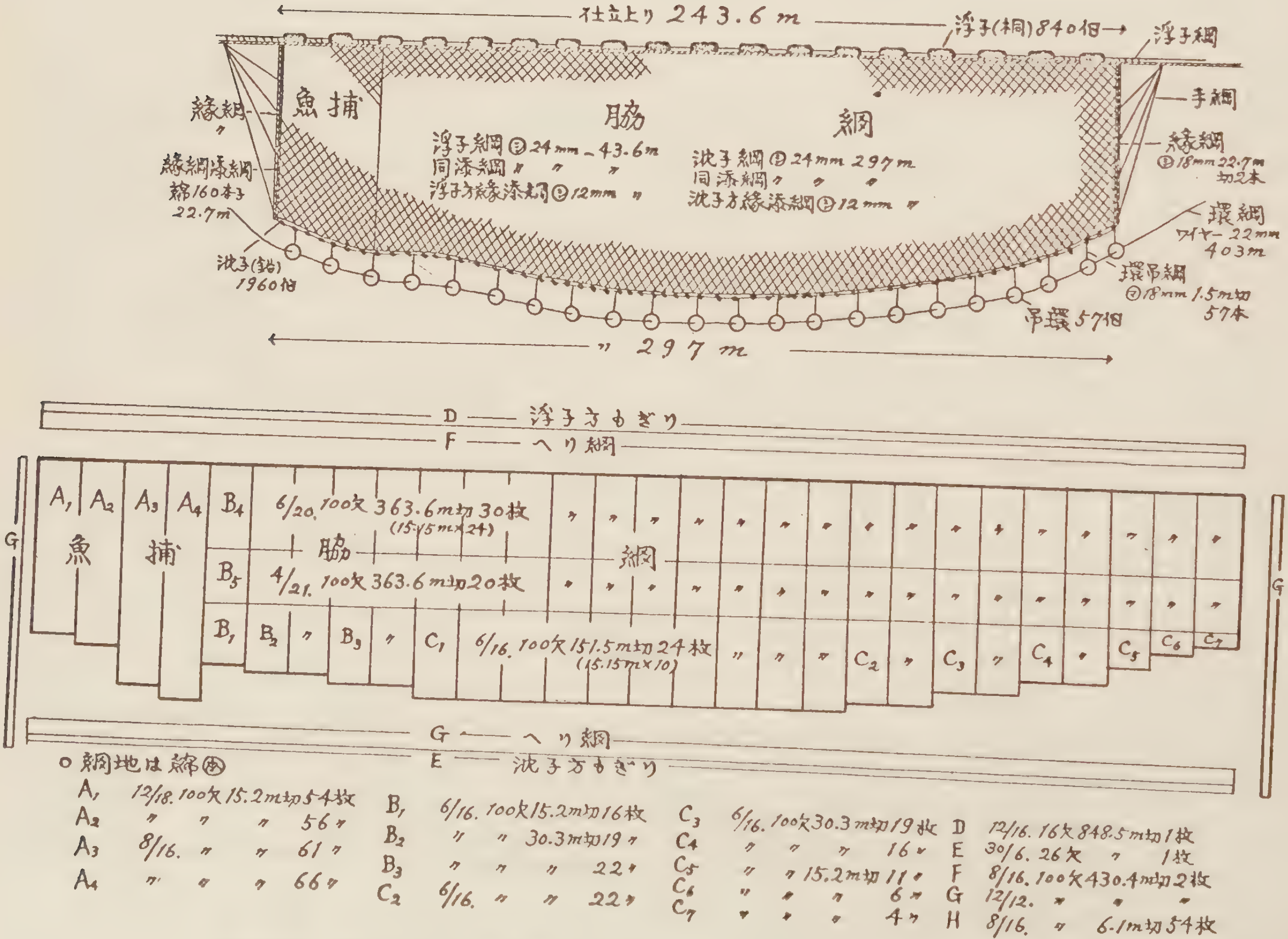
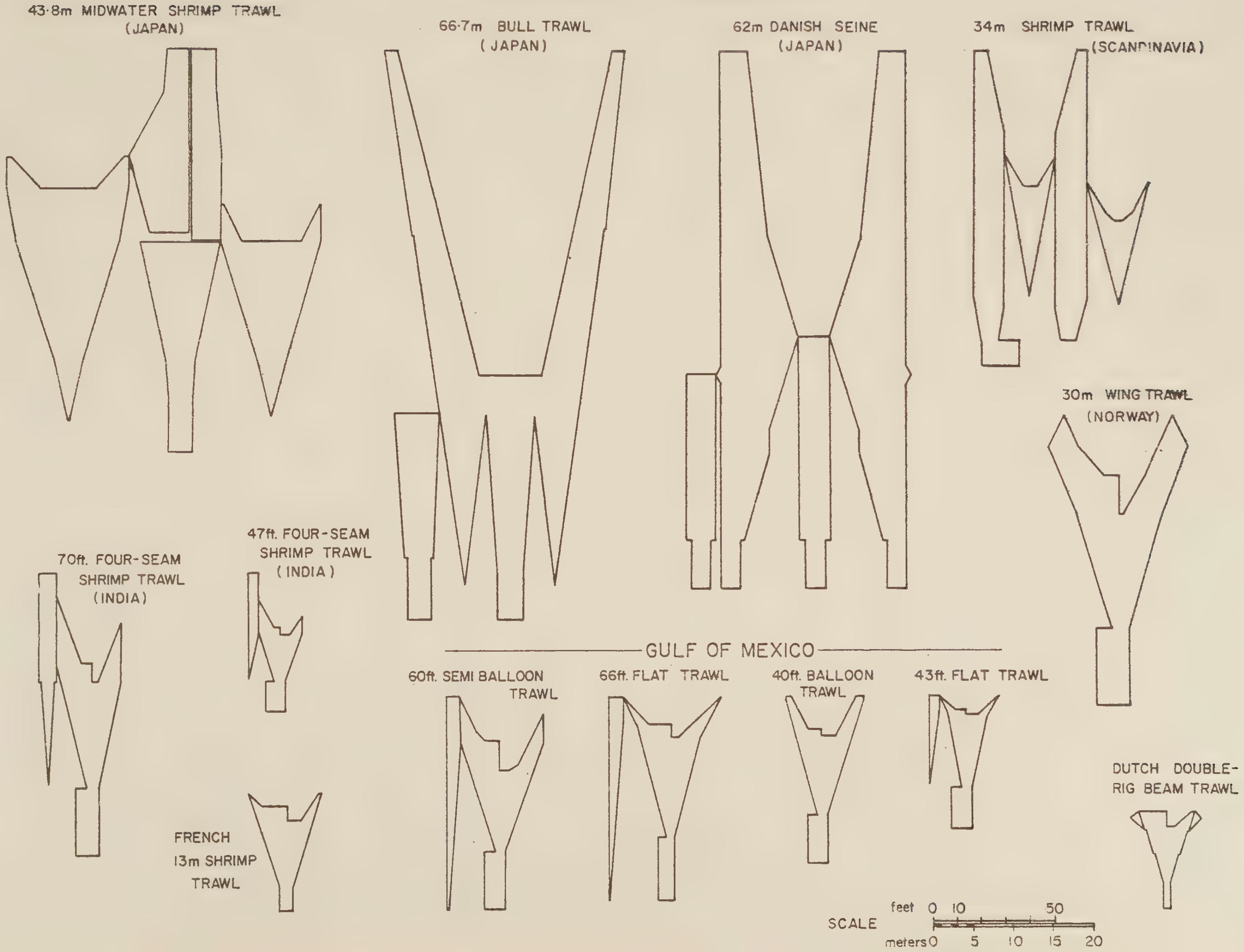


Fig.56 Japanese one-boat purse seine for shrimp and sardine.
Species caught: Metapenaeus joyneri.

COMPARATIVE SIZES OF SHRIMP TRAWLS



Big two-boat roundhaul seines (over 500 m long) are also used from small motorboats for catching Sergestes lucens. This is a very small bioluminescent species of shrimp (max. length about 50 mm), which normally stays deep during the daytime and is fished when it rises (like a deep scattering layer) at night, especially in Shizuoka Prefecture (Fig. 5).

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OBSERVACIONES SOBRE LAS MEDIDAS DE CONTROL DE LOS RECURSOS ACUATICOS VIVIENTES CON REFERENCIA ESPECIAL AL CAMARON

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Extracto

Este estudio se preparó originalmente con el propósito de resumir en un solo documento, en español, algunos principios enunciados por biólogos pesqueros de varios países desarrollados, en relación con la administración científica de los recursos acuáticos vivientes, teniendo en cuenta especialmente que estos criterios son en ocasiones ignorados por biólogos de los países hispánicos que no poseen la facilidad necesaria para leer en otros idiomas. Se hace notar que algunos aspectos están todavía en discusión entre los especialistas, cuyas opiniones pueden consultarse en las publicaciones citadas en las Referencias.

NOTES ON THE MANAGEMENT OF THE LIVING AQUATIC RESOURCES WITH SPECIAL REFERENCE TO SHRIMP

Abstract

This study was originally prepared with a view summarizing in one paper, in Spanish, certain principles worked out by fishery biologists in the developed countries in respect of resource management, having specially in mind that these criteria are sometimes ignored by biologists in Spanish speaking countries who do not read fluently in other languages. Attention is called to those aspects on which there is not yet unanimous agreement between specialists, whose views may be consulted in the publications cited in the References.

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OBSERVATIONS SUR LE CONTROLE DES RESSOURCES VIVANTES DE LA MER, PARTICULIEREMENT EN CE QUI CONCERNE LES CREVETTES

Résumé

Ces observations avaient été rédigées en vue de donner, en un seul document, un résumé, en langue espagnole, de certains principes énoncés par des biologistes de pêcheries de pays developpés quant à l'utilisation des ressources, ceci dans l'idée que certains de ces critères sont parfois ignorés des biologistes des pays de langue espagnole qui ne lisent pas couramment d'autres langues. On attire spécialement l'attention sur certains aspects au sujet desquels il n'y a pas encore accord unanime entre les spécialistes; on peut connaître les points de vue de ces derniers en se reportant aux publications citées dans les Références.

1 INTRODUCCION

En este trabajo no se pretende presentar criterios nuevos. Su objeto es recopilar en un solo documento, en español, ciertos importantes aspectos, lo que es, en la opinión del autor, indispensable tener presente en cualquier programa encaminado hacia la administración de los recursos acuáticos vivientes. Se ha intentado no tomar posiciones en cuanto a algunos puntos de vista que todavía son materia de discusión entre los expertos en esta compleja disciplina, ni tampoco se ha creido conveniente entrar en consideraciones altamente técnicas en que están involucrados conceptos matemáticos que a esta altura podrían oscurecer la presentación clara y sencilla de ciertos criterios elementales cuyo valor para los que quieren embarcarse en los estudios detallados de los recursos pesqueros, es indiscutible. En cambio, para los que buscan profundizarse en esta disciplina muy especializada, se recomienda el cuidadoso estudio de la voluminosa literatura que existe sobre la materia, de la cual se consigna apenas una fracción en las Referencias adjuntas.

El término "management"1/, como aquí se usa, no debe interpretarse en el sentido adoptado por algunos naturalistas, como un beneficio que se proporciona a los propios organismos, ni tampoco se trata de evitar la desaparición de especies de interés científico, sino la óptima explotación de los recursos naturales vivientes, proyectada en un futuro indefinido. En otras palabras, y tratándose de las pesquerías, lo que interesa no es precisamente el estudio de los peces en sí, sino por una parte, la relación que existe entre el género humano y estos organismos, colectivamente, y por otra, las medidas que es factible tomar para mejorar esta relación en favor del hombre.

Hasta la mitad del siglo pasado, existía el concepto, expresado por eminentes naturalistas, que los recursos del mar eran tan inmensos que cualquier esfuerzo del hombre no los afectaría.

Sin embargo, con la introducción de la propulsión mecánica se hizo evidente que no era así. En las áreas tradicionales de pesca se empezó a ver una reducción en el rendimiento por barco, como también una disminución en el tamaño promedio del pescado y, en algunos casos, una reducción de la cantidad capturada por la flota total. Estos hechos estimularon el desarrollo de artes más eficientes y el uso de barcos más grandes para compensar la tendencia de disminución en la pesca de los barcos originales, y este desarrollo a su vez aumentó el efecto de la sobrepesca.

El otro efecto ha sido una nueva preocupación de los gobiernos (cuyas funciones eran antes muy limitadas) para contrarrestar un progresivo agotamiento de los recursos acuáticos. Aún no existían estudios serios sobre el comportamiento de las poblaciones acuáticas y muchas de las medidas que se proponían eran extensiones empíricas del conocimiento más directo, pero en sí imperfecto, de los animales terrestres.

El estudio científico del efecto de la pesca en el mar empezó prácticamente con la colaboración entre los gobiernos europeos en el seno de la Comisión Internacional para la Exploración del Mar, cuyas importantes labores se afinan constantemente después de más de medio siglo.

Estas investigaciones resultaron, entre 1930 y 1940, en la formulación por Hjort, Russell, Graham y otros, de ciertos conceptos en cuanto al efecto de la pesca sobre los stocks de peces y sobre el rendimiento de los barcos. En este período también hubo notables avances en el estudio de la ecología de poblaciones terrestres (Nicholson, Elton y otros).

1/ El término inglés "management" no tiene traducción exacta en español; el concepto más aproximado sería: "medidas de control o control científico del recurso".

El biólogo I.E. Baranov (1918) ya había establecido ciertos modelos matemáticos de estas relaciones, es decir, de los cambios en la pesca y en las concentraciones (poblaciones) de peces en función de la mortalidad pesquera, en peces con diferentes características de crecimiento y de mortalidad natural. Más recientemente, una serie de autores (Beverton, Holt, Schaefer, Ricker y otros) contribuyeron al desarrollo de modelos matemáticos para el estudio de estos fenómenos.

Todos estos trabajos han contribuido al entendimiento de la influencia que la pesca ejerce sobre los stocks de peces, y de las posibilidades que existen para cambiar esta influencia. Ahora es posible estimar el efecto de un cambio en la edad o en el tamaño cuando los peces entran por primera vez en la pesquería; o de un cambio en la mortalidad de pesca, sobre la pesca total y sobre el rendimiento por unidad de esfuerzo, etc. Todo esto ha dado lugar al concepto de la curva eumétrica, o sea una curva que indica la cantidad máxima de pescado que se puede obtener con diferentes intensidades de pesca, y las variaciones dentro de cada intensidad si se ajustara la selectividad de las redes.

Es necesario decir aquí que, siendo ésta una ciencia nueva, aún no existe, y tal vez nunca existirá, la unanimidad absoluta entre los autores en cuanto al efecto preciso de los varios factores que influyen en estos modelos matemáticos. Sin embargo, en el curso de los años se han esclarecido los principios básicos que permiten llegar a conclusiones generalmente válidas en cuanto a la filosofía de la preservación de los recursos, o sea la óptima utilización, sin poner en peligro el rendimiento futuro. Las medidas de control de una pesquería marina representan el equilibrio entre el pescado extraído de la población, sea por el hombre o por otros medios, y el aumento de ella como resultado del proceso natural de la reproducción (y reclutamiento). El punto preciso de este equilibrio solamente se determina para cada pesquería mediante el conocimiento de las características de las especies que constituyen la pesquería y mediante experimentos. Así mismo, la reglamentación es un continuo experimento orientado hacia el logro del referido equilibrio; por lo tanto, la constante observación y estimación del efecto real de la reglamentación es de una importancia primordial (Clark, 1936).

Es tal vez útil recordar aquí algunos de los aspectos teóricos en cuanto al efecto del esfuerzo pesquero del hombre sobre un recurso pesquero (Baranov, 1918; Schaefer, 1954; Shimada y Schaefer, 1956. Resumen hecho por Shimada y Schaefer (1956) de las conclusiones de los precitados autores). "Una población de peces en el mar, en común con todos los conglomerados de cosas vivientes, tiene la facultad de renovarse y de aumentar su tamaño por la reproducción y el crecimiento. Sin embargo, los efectos de la densidad de población sobre la mortalidad natural y el reclutamiento tienden a limitar la magnitud final que puede alcanzar una población y la tasa de crecimiento de los individuos es también afectada por la densidad de la población. De este modo, la tasa en que una población crece en peso depende de la relación cuantitativa entre el nacimiento (o reclutamiento) y crecimiento por una parte y la mortalidad por la otra. Cuando los factores de aumento exceden a los factores de decrecimiento, la población aumenta y por el contrario, si las remociones son mayores que los incrementos, la población declinará en tamaño.

"No obstante, bajo condiciones naturales las poblaciones pocas veces llegan a extinguirse ni tampoco a crecer indefinidamente. Por lo general, los renuevos tienden a igualar las pérdidas, de modo que la magnitud de la población se mantiene en equilibrio a un nivel promedio que es determinado primordialmente por el medio ambiente. Si en cualquier momento una influencia adicional viene a afectar la población, como cuando el hombre explota parte de ella, entonces busca un reajuste ante este nuevo factor de mortalidad y se estabiliza a un nuevo nivel. Esta innata habilidad de una población de peces para contrarrestar el incremento en la mortalidad originado por la explotación humana, se define como 'base biológica de una pesquería de rendimiento sostenido'".

Ahora, ¿cuáles son aquellas medidas con que el hombre puede afectar el recurso? Solamente en las masas acuáticas cerradas (estanques y pequeñas lagunas) es posible modificar favorablemente las condiciones ambientales mediante la fertilización artificial de las aguas, el suministro de forraje, etc. Pero esta posibilidad decrece rápidamente en proporción indirecta con el tamano de la cuenca, hasta desaparecer por completo tratándose de pesca en alta mar. Tampoco es posible, hasta ahora, influir ni sobre la reproducción (o reclutamiento) ni sobre la mortalidad natural. Por lo tanto, de los factores que influyen sobre la pesca en cuanto a su rendimiento, apenas dos pueden ser controlados directamente por el hombre: la mortalidad causada por la pesca, que está en relación con el esfuerzo pesquero; y en menor grado, el tamaño en que el pez se hace vulnerable a la pesca (Gulland, 1960).

Es evidente que este control no debe aplicarse caprichosamente, sino cuando se demuestra la necesidad del mismo, mediante cuidadosas y completas investigaciones científicas. Se estudiarán a continuación las diferentes modalidades posibles conducentes al control del esfuerzo pesquero.

2 CONTROL SOBRE EL NUMERO DE PERMISOS

Cuando empieza una nueva pesquería, las capturas son mucho más grandes que las que se han de ver más tarde. Esto se debe a que se está aprovechando no solamente el aumento natural proveniente del proceso de reproducción o renovación, sino principalmente la cosecha acumulada. Desafortunadamente, en ausencia de una política de control sobre el número de unidades, los grandes pero pasajeros beneficios de esta primera etapa pueden aumentar la tendencia de sobreexpansión de la flota, cuyos costos de operación serán altos en comparación con el rendimiento, una vez establecido el punto de equilibrio. En condiciones de libre competencia, ésto daría lugar a una situación en la cual las unidades menos eficientes pierden dinero y desaparecen por bancarrota, pero sin embargo el número de barcos que queda es normalmente mayor que el óptimo y resulta en una producción total que es igual a, o en muchos casos menor que la producción que se puede obtener con menor número de barcos.

Esta situación es desastrosa, ya que en lugar de ir en aumento, se merma innecesariamente la explotación total de un valioso recurso. Existen fórmulas para calcular el probable efecto de una disminución en la flota u otra restricción, siempre que hayan acumulado los datos bioestadísticos necesarios durante varios años.

Teniendo en cuenta que la eliminación de barcos una vez incorporados en la flota puede traer grandes dificultades administrativas, es obviamente preferible tomar las medidas necesarias para evitar una sobreexpansión de la flota antes de que ocurra y no después, mediante cuidadosos cálculos del probable rendimiento, sujeto a ajustes posteriores a la luz de los resultados continuamente medidos.

Es necesario también tener en cuenta que las circunstancias reinantes en las pesquerías por stocks con distribución limitada dentro de las aguas territoriales de un país, donde es posible un control absoluto del número de permisos, son distintas a las de los stocks con distribución en alta mar, donde las condiciones de competencia exigen un máximo esfuerzo, a menos que se logre el control de la flota mediante un convenio internacional basado en investigaciones formales.

3 EPOCAS Y AREAS DE VEDA

Es muy importante, al estudiar las ventajas o desventajas de las vedas, comprender que las circunstancias varían enormemente de acuerdo con las diferentes especies y características ambientales.

Tratándose de un animal de crecimiento lento y de infrecuente y poco numerosa reproducción (mamíferos en general), las leyes naturales serán muy distintas a las que rigen para uno de corta vida y con abundancia de huevos. Típicos de este caso son los camarones tropicales (Penaeidae) y las anchovetas.

Si se calcula que la vida de ambos dura poco más de un año, es obvio que durante cualquier mes de veda se perderá un cierto porciento del número total disponible, por mortalidad natural. La tasa de mortalidad natural es en el caso del camarón blanco, (Penaeus setiferus), 25 porciento o más del número original cada mes acumulativo (Lindner, 1959; Ingle, 1961). Según este cálculo, de 1000 ejemplares presentes en un momento determinado, se pierden 250 en el primer mes y 190 en el segundo, o sea el 44 porciento en el curso de dos meses, y así sucesivamente 1/, hasta dejar un número insignificante al final del año.

Afortunadamente, el rápido crecimiento de los crustáceos peneidos compensa esta enorme pérdida numérica con el rápido aumento en el peso de los ejemplares que sobreviven. Sin embargo, para justificar una veda de un mes sería necesario comprobar que el valor de los 750 restantes de los mil ejemplares originales, disponibles para la flota, ha adquirido, por su crecimiento, un valor superior al de los 1000 originales. En dos meses el valor adicional por concepto de crecimiento debería compensar un 44 porciento de pérdida, en números, y así sucesivamente.

Según algunos autores, la tasa de crecimiento de los camarones tropicales del norte del Golfo de México en sus primeros meses de vida es mayor que el peso perdido en los ejemplares que sucumben a la mortalidad natural (Gunter, 1956; Ingle, 1961). Lindner (1959) sugiere que esta tendencia persiste hasta una tamaño aproximadado de 50 colas por libra, pero según sus cálculos después de este punto la mortalidad empieza a exceder el aumento en peso de los sobrevivientes. Según este autor (citado por Ingle) la protección de individuos mayores de este tamaño no aumenta, y probablemente disminuye el valor de la pesca.

Otros autores (Kutkuhn, 1966) van más lejos, y sostienen que, excepto en condiciones muy leves de mortalidad natural, el tamaño óptimo para la captura de los camarones tropicales es el momento en el cual adquieren valor comercial, que puede ser alrededor de 70 colas por libra (154 por kilógramo).

Para llegar a conclusiones más definitivas, es necesario continuar las investigaciones de crecimiento y mortalidad.

Sobre la conveniencia o contraindicación de la pesca de juveniles, Ricker (1954), después de constatar que no existe una sola regla uniforme aplicable para el control de todas las pesquerías, y que deben estudiarse todas las circunstancias de cada caso, agrega que en cualquier caso particular, es posible que el máximo rendimiento económico se logre tomando sea los juveniles, sea sólo los adultos, sea unos con otros. Un prejuicio en principio contra la captura de juveniles, sin más razones que las que se basan en una actitud emocional, carece de solidez. Al estudiar las posibles alternativas, es importante tomar en cuenta el valor relativo por kilo de los diferentes tamaños, y la relativa facilidad (y costo) de captura.

Otro efecto de esta alta tasa de crecimiento es que, en cualquier año se captura, sin que haya sobrepesca, entre 120 y 150 porciento del peso total de la cosecha existente en cualquier época en el mismo año. Este hecho curioso hace aún más dudosa la conveniencia de una veda, tratándose del camarón. Además, Baranov (1918) anota que la mayoría de este tipo de restricciones no logran sus objetivos..."la introducción de una veda temporal resulta en una pesca más intensa en el resto del año".

Se hace necesario agregar aquí que el antiguo argumento que se debe proteger a las hembras con hueva, se ha abandonado por completo. Según los conceptos recientes, el número de reproductoras necesario para reponer aún la pesca más fuerte, es sumamente pequeño, y normalmente habrá (aunque sea solamente en áreas no accesibles a la pesca)

1/ Según los últimos informes Lindner, al revisar sus cálculos, estima que la mortalidad natural es aún mayor que el 25 por ciento mensual.

un escape suficiente para asegurar la amplia renovación del recurso para la cosecha siguiente.

Dicho de otra manera, la restricción de la pesca por cualquier medio que sea, no se justifica si el objeto es meramente aumentar el número de reproductores (numerosos autores, por ejemplo Ingle, 1961)[1] y existen pocos ejemplos en los que el número de reproductores en una población de peces marinos tenga influencia sobre el número resultante de juveniles. Esto no es sorprendente si se recuerda que cada hembra produce vastas cantidades de huevos (Gulland, 1953) y que cada pareja de reproductores apenas tiene que producir dos reclutas que a su vez se reproduzcan (Sprules, 1959).

Existe en la actualidad una discusión interesante en las revistas pesqueras que gira alrededor de la reciente decisión de las autoridades británicas, asesoradas por sus biólogos pesqueros, de suspender la prohibición de comerciar en langostas con huevas, ya que se ha llegado a la conclusión de que no es este aspecto el que ejerce un efecto principal sobre la población de langostas (que son aún más vulnerables que el camarón a la sobrepesca). Pero tal vez lo más interesante es que los pescadores de langosta, convencidos por su sentido común y haciendo caso omiso de la evidencia científica, desean continuar esta restricción, que es el caso contrario a lo que se encuentra en muchas partes.

A primera vista parecería que la veda constituye una manera de reducir la presión pesquera total anual. Sin embargo, según los argumentos aducidos, es la manera menos eficiente y económica de lograr esta restricción de esfuerzo, no solamente por las pérdidas por mortalidad natural durante la veda, sino porque la reducción de esfuerzo no es efectiva, pues la flota tiende a pescar más intensamente en las épocas no vedadas.

La veda por zonas en aguas protegidas es en cambio un problema diferente y es necesario estudiarlo separadamente, teniendo en cuenta una serie de factores bastante complejos. Aunque obviamente conviene evitar el desperdicio económico que resultaría de la captura masiva de ejemplares muy pequeños antes de que adquieran un valor significativo, tampoco es el caso de adoptar una política de excesiva protección de ejemplares de tamaños que sean comerciales, a menos que una investigación completa que abarque los factores biológicos (reclutamiento y mortalidad) y las condiciones económicas de la pesquería, indique claramente la necesidad de cierto grado de restricción.

4 CONTROL DE TAMAÑO DE PRIMERA PESCA

En cuanto a la posibilidad de controlar el tamaño de primera pesca, esto depende principalmente de las restricciones que se impongan sobre el tamaño de malla permitido en las redes. No es el caso entrar a discutirlo aquí, ya que se trata de alta especialización. Basta notar que una malla más ancha implica un empleo más eficiente de las máquinas, y además deja escapar peces y crustáceos inmaturos.

Uno de los efectos más comunes del establecimiento por ley de tamaños mínimos ha sido que por verse obligado a cumplir con la letra el reglamento, el barco devuelve al mar los ejemplares pequeños ya muertos. En este caso tal restricción, lejos de fomentar un mejor aprovechamiento del recurso, puede dar lugar a un desperdicio innecesario.

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[1] Aunque este argumento podría interpretarse en el sentido de justificar cualquier aumento en la flota, no es así, porque cualquier presión que se genera en exceso del óptimo resultaría en una reducción en el peso total de las capturas.

También ejerce influencia sobre el tamaño de primera pesca la prohibición de pescar en áreas de crianza - por ejemplo en lagunas, esteros y otras áreas de poquísima profundidad - donde algunas especies de camarón pasan los estadios larvales y postlarvales de su vida. Hemos hablado sobre este aspecto en otro lugar, pero conviene repetir aquí la necesidad de mantener cierta elasticidad de criterio en el sentido de cerrar a la pesca solamente aquellas zonas donde la investigación demuestra la necesidad de ello, y que la reglamentación en cuanto a vedas por áreas debe estar sujeta a modificaciones según las indicaciones científicas.

5 OTRAS RESTRICCIONES

La intensidad de la pesca puede también ser controlada por una serie de otras medidas, como cuotas, vedas temporales, limitación del tamaño (o potencia) del barco y del tipo de arte. Sin embargo, se ha constatado que algunas de estas medidas reducen la eficiencia de la pesquería y es necesario, por lo tanto, examinar cuidadosamente todos los factores reinantes en cada caso antes de tomar medidas precipitadas.

Si es cierto que las cuotas tienen el efecto de limitar el esfuerzo de pesca, sin embargo, no impiden sobreexpansión de la flota. No obstante, el sistema de cuotas puede ser útil cuando se emplea para repartir partes del esfuerzo total entre diferentes grupos interesados. En este caso, cada grupo podría organizar su propio esfuerzo de la manera más económica. Pero tenemos que añadir que es importante, antes de adoptar este método conocer muy bien el rendimiento sostenible del stock y adaptar las reglamentaciones a las fluctuaciones anuales del recurso.

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UNIT STOCKS OF SHRIMPS AND PRAWNS IN THE IPFC REGION AND UNIT FISHERIES EXPLOITING THEM

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Abstract

The author summarizes the existing knowledge of the distribution of shrimp and prawn species of economic value, and the main methods used for their capture and culture in the different countries of the Indo-Pacific Region.

Of the two main groups of species referred to, 51 belong to Penaeidea and 43 to Caridea. The largest species representation is from the genus Macrobrachium.

UNITES DE STOCKS DE CREVETTES DE LA REGION DU CIPP ET CATEGORIES DE PECHES LES EXPLOITANT

Résumé

L'auteur résume ce que l'on sait de la répartition des crevettes d'intérêt économique et des principales méthodes employées pour leur capture et leur élevage dans les divers pays de la région indo-pacifique.

Parmi les espèces des deux grandes catégories mentionnées, 51 appartiennent aux Penaeidea et 43 aux Caridea. C'est le genre Macrobrachium qui fournit le plus grand nombre d'espèces.

UNIDADES DE STOCKS DE CAMARONES Y GAMBAS EN LA REGION DEL INDO-PACIFICO Y UNIDADES DE PESQUERIAS QUE LOS EXPLOTAN

Extracto

El autor hace un sumario de los conocimientos actuales sobre la distribución de las especies de valor comercial de camarones y gambas, y de los principales métodos usados para su captura y cultivo en los diferentes países de la región del Indo-Pacífico.

De los dos grupos principales de especies a que se refiere, 51 son Penaeidea y 43 Caridea. La especie representada más ampliamente pertenece al Genus Macrobrachium.

1 INTRODUCTION

This paper has been prepared by the author at the request of the Indo-Pacific Fisheries Council at the 11th Session in Kuala Lumpur, Malaysia, in 1964, and is based on catalogues of unit fisheries and research project summaries sent to him by representatives of various Member Governments at the request of the Council. There was no response from a few countries and the information relating to these countries was obtained from the past proceedings of the Indo-Pacific Fisheries Council in order to complete the picture as far as possible.

2 SHRIMP RESOURCES OF THE REGION

The list of species of shrimps and prawns of economic value prepared by Holthuis and Rosa (1965) gives a very comprehensive picture of the commercially important species which have been reported from the region. The distribution of the Penaeidea and Caridea in the region is given in Table I. In preparing this table, the region is divided into six sectors as follows:

TABLE I

I	Saudi Arabia, Yemen, Aden, Muscat and Oman, Trucial Oman, Kuwait, Bahrein, Iraq, Iran, Afghanistan
II	Pakistan, India, Ceylon
III	Southeast Asia: Burma, Thailand, Malaysia, Singapore, Indonesia, Philippines, Cambodia, Vietnam, Laos
IV	East Asia: Chinese Peoples' Republic, Hong Kong, Macau, Korea, Mongolian Peoples' Republic, Japan, Formosa
V	Australia, New Guinea, New Zealand
VI	Eastern Oceania, Hawaii, Pacific Islands

The total number of species listed by Holthuis and Rosa (1965) for the region is 94. The breakdown by genera is as follows:

		Number of Species		
Section 1	PENAEIDEA	51		
Family:	PENAEIDAE		46	
(a)	Atypopenaeus			1
(b)	Metapenaeus			13
(c)	Metapenaeopsis			4
(d)	Parapenaeopsis			9
(e)	Parapenaeus			1
(f)	Penaeopsis			1
(g)	Penaeus			14
(h)	Trachypenaeus			3
Family:	SERGESTIDAE		5	
(a)	Acetes			4
(b)	Sergestes			1

		Number of Species		
Section 2	CARIDEA	43		
Family:	ATYIDAE		8	
(a)	*Atya*			2
(b)	*Caridina*			6
Family:	PALAEMONIDAE		29	
(a)	*Leptocarpus*			2
(b)	*Macrobrachium*			22
(c)	*Palaemon*			5
Family:	ALPHEIDAE		2	
(a)	*Alpheus*			2
Family:	PANDALIDAE		3	
(a)	*Pandalus*			3
Family:	CRANGONIDAE		1	
(a)	*Crangon*			1

The number of species of Caridea is only slightly lower than that of Penaeidea. In the section Penaeidea, two families, viz: Penaeidae and Sergestidae are represented. Among the Penaeidae, the genera *Penaeus* (14 species), *Metapenaeus* (13 species) and *Parapenaeopsis* (9 species) predominate. Among the Sergestidae, the genus *Acetes* predominates. In the section Caridea 5 families are represented. Most of the species are from the families Palaemonidae (29 species) and Atyidae (8 species). In the family Palaemonidae, most of the species are from the genus *Macrobrachium* (22 species).

3 DISTRIBUTION

The following table provides a picture of the distribution of the Penaeidea and Caridea by geographical sectors in the region.

TABLE II

	Sector	Number of species Penaeidea	 Caridea	 Total
I	Arabia to Afghanistan	4	0	4
II	Pakistan, India, Ceylon	33	19	52
III	Southeast Asia	36	33	69
IV	East Asia	23	13	36
V	Australia, New Guinea, New Zealand	22	7	29
VI	Eastern Oceania, Hawaii, Pacific Islands	3	6	9

The number of species recorded is highest in the South and Southeast Asian sectors. Whilst it may be that the small number of species recorded in sector I is due to the fact that the shrimp fauna has not perhaps been studied as thoroughly as in other sectors, the general picture is that the number of species in sectors II and III is higher than that in the other sectors. This is in part also due to the large number of species of *Macrobrachium* recorded, especially those in the southeast Asian sector.

Among the members of the genus *Penaeus*, certain species such as *P. semisulcatus* has been recorded in all sectors of the region, except Eastern Oceania and the islands of the Central Pacific, whilst others such as *P. monodon* and *P. penicillatus* have been recorded in all sectors except the extreme sectors, i.e. the western and eastern sectors of the region. On the other hand certain species are only found in certain sectors, e.g. *P. plebejus* only in the Australian sector, *P. marginatus* only in the central Pacific Islands, and *P. orientalis* only in the eastern sector (Japan). The distributional pattern of the other genera in the Penaeidea appears to be the same. In the section Caridea many of the species are common to two sectors, e.g. the south Asian and southeast Asian sectors. The number of species recorded for these two sectors is also comparatively high.

The members of the Penaeidea are all marine though quite often they are found in coastal and swampy areas where the water is usually of the high salinity brackish type. All the members of the Penaeidae, with one or two exceptions, e.g. in the case of the genus *Metapenaeus*, breed fairly far out at sea. The general picture is that the larval stages move towards the coastal areas to grow up and return to the off-shore grounds on maturity to breed. The members of the Caridea, on the other hand, are predominantly freshwater, in particular the members of the genus *Macrobrachium*. There are exceptions, e.g. *Macrobrachium equidens*, *M. rosenbergii*, and *Caridina propinqua*, which according to Johnson (1962), may be found in brackish water. *Palaemon styliferus* and *Palaemon tenuipes* are also found in brackish water.

4 COMMERCIAL VALUE OF DIFFERENT SPECIES

The group which commands the highest prices in the markets are the members of the genus *Penaeus* as these species grow to a large size. This is so because of the world-wide great demand for these species. The members of the genus *Metapenaeus* come next in commercial value and they are in great demand by local consumers. To this group may also be included the larger members of the section Caridea, such as *Macrobrachium rosenbergii*. The other members of the section Penaeidea have a lower value and in South and Southeast Asia they are generally processed and sold as dried shrimps, or in the case of the Sergestidae, they are converted into shrimp paste. The majority of the members of the section Caridea are small and have fairly thick shells. Most of them are mature at a length of 40 to 60 mm. Their commercial value is very much lower.

5 UNIT STOCKS

Generally speaking, the unit stocks in the region may be placed in three categories, viz:

(1) Stocks in the offshore region which consist mainly of the members of the genus *Penaeus*

(2) Stocks in the coastal and estuarine region which consists mainly of the other members of the section Penaeidea and the brackish water members of the section Caridea

(3) Stocks in the rivers and lakes which consist of the bulk of the members of the section Caridea

There is, however, no clear line of demarcation because many species of the genus Penaeus are caught by fishing methods employed in the coastal areas and this applies also to many Carideans which are also caught in the coastal and estuarine regions.

On the other hand, the unit stocks of different countries for each of the categories given above also differ in specific composition. Whilst there are many species which are common to the unit stocks of each category for several countries, e.g. Penaeus indicus which may be included in the unit stocks of India, Pakistan, Malaysia, Singapore, Philippines, there are other species which are specific for the unit stocks of particular countries, e.g. Penaeus plebejus, Metapenaeus endeavouri and M. macleayi for Australia, Penaeus orientalis, Metapenaeus burkenroadi, M. joyneri, M. acclivis for Japan, Pandalus borealis, Pandalus hypsinotus for Korea. The information available from the different countries are summarized in Table III.

6 UNIT FISHERIES

The main methods used for the capture and culture of shrimps in the different countries are as follows:

6.1 Shrimp trawls

These trawls are either otter trawls or beam trawls. In certain countries, such as Australia, fairly large powered boats, ranging from 20 to 75 ft (6 to 23 m) in length, with otter trawls are used and the unit stock exploited consists of species of Penaeus and Metapenaeus. In Korea otter trawls are also used but the unit stock exploited consists of species of Pandalus. The beam trawls are used in estuarine areas. The unit stock exploited by these beam trawls is similar, except that in certain countries, such as Australia, certain species such as Penaeus esculentus, P. plebejus and P. latisulcatus are apparently not caught. In certain countries they are operated throughout the year, whilst in others they are operated only during part of the year. Trawls are also used in Malaysia, Philippines, Cambodia and Korea.

6.2 Seine nets

These nets are hauled in on the beach or from the boat and their shrimp catches are incidental to the catch of fish. They are operated from small non-powered vessels in the inshore areas. They are operated in India, Pakistan, Malaysia, Philippines, Singapore and Korea. In Malaysia and Singapore they are operated throughout the year. The unit stock exploited consists of species of Penaeus and Metapenaeus.

6.3 Filter nets

These nets are fixed conical nets in the form of bags operated either with or without wings of netting or bamboo barriers on each side of the bag, anchored to the bottom with stakes and facing the tidal current so that the shrimps are filtered by the bag as they float with the current. They are known as conical nets or filter nets, or set pocket nets in different countries, and are operated in the coastal, estuarine or riverine areas in Ceylon, India, Pakistan, Philippines, Malaysia, Singapore and Australia. The unit stock exploited depends on the location. In the coastal areas it consists mainly of Penaeidae mixed with brackish water species of Carideans, and in the riverine areas it consists of freshwater Carideans. In Ceylon the nets are operated on dark nights and flares are placed above the mouth of the bags to attract the shrimps. In Malaysia they are operated throughout the year.

6.4 Barrier nets

These nets are fine-meshed and set at high tide parallel to the beach to enclose a certain area of sea and the shrimps are caught when the tide recedes. A certain amount of fish is caught at the same time. This net has been reported only from Malaysia. The unit stock exploited consists of Penaeids and fish. It is operated throughout the year.

TABLE III

Species commonly found in shrimp catches of different countries

	INDIA	PAKISTAN	MALAYSIA	SINGAPORE	CAMBODIA	PHILIPPINES	JAPAN	KOREA	AUSTRALIA
SECTION 1. PENAEIDEA FAMILY PENAEIDAE									
Genus Penaeus									
P. indicus	x	x	x	x	-	x	-	-	-
P. esculentus	-	-	-	-	-	x	-	-	x
P. merguiensis	-	x	x	x	-	x	-	-	x
P. latisulcatus	-	-	-	-	-	-	-	-	x
P. plebejus	-	-	-	-	-	-	-	-	x
P. penicillatus	-	x	x	-	-	-	-	-	-
P. canaliculatus	-	x	-	-	-	x	-	-	-
P. semisulcatus	-	x	x	x	-	-	-	-	-
+ P. carinatus = P. monodon	x	x	x	-	x	x	x	-	x
P. japonicus	-	-	-	-	-	-	x	-	-
P. orientalis	-	-	-	-	-	-	x	-	-
Genus Metapenaeus									
M. monoceros	x	x	x	-	-	-	-	-	-
M. affinis	x	-	x	-	-	x	-	-	-
M. dobsoni	x	-	x	-	-	-	-	-	-
M. brevicornis	x	x	x	x	-	-	-	-	-
M. macleayi	-	-	-	-	-	-	-	-	x
M. mastersii = M. ensis[1]	-	-	-	x	-	-	-	-	x
M. endeavouri	-	-	-	-	-	-	-	-	x
+ M. incisipes = M. ensis	-	-	-	-	-	x	-	-	x
M. burkenroadi	-	-	-	-	-	-	x	-	-
M. joyneri	-	-	-	-	-	-	x	-	-
M. ensis	-	-	x	x	-	x	x	-	-
M. lysianassa	-	x	x	x	-	-	-	-	-
+ M. mutatus = M. affinis	-	-	x	x	-	-	-	-	-
+ M. intermedius	-	-	-	x	-	-	-	-	-
+ M. elegans	-	-	-	x	-	-	-	-	-
+ M. spinulatus = M. tenuipes	-	-	-	x	-	-	-	-	-

[1] Most Australian records pertain to M. bennettae, and the Singapore records to M. burkenroadi

TABLE III (cont'd)

	INDIA	PAKISTAN	MALAYSIA	SINGAPORE	CAMBODIA	PHILIPPINES	JAPAN	KOREA	AUSTRALIA
Genus Metapenaeopsis									
+ M. stridulans	-	-	x	-	-	-	-	-	-
M. acclivis	-	-	-	-	-	-	x	-	-
M. barbata	-	-	-	-	-	-	x	-	-
M. novaeguineae	-	-	-	-	-	-	-	-	x
Genus Parapenaeopsis									
P. stylifera	x	x	x	-	-	-	-	-	-
P. uncta	-	x	-	-	-	-	-	-	-
P. tenella	-	-	x	-	-	-	-	-	-
P. hungerfordii	-	-	x	-	-	-	-	-	-
P. hardwickii	-	-	x	-	-	-	-	-	-
P. coromandelica	-	-	x	-	-	-	-	-	-
P. maxillipedo	-	-	x	-	-	-	-	-	-
P. sculptilis	-	x	x	-	-	-	-	-	-
Genus Trachypenaeus									
T. fulvus	-	-	x	-	-	-	-	-	-
T. curvirostris	-	-	-	-	-	-	x	-	x
T. anchoralis	-	-	-	-	-	x	-	-	x
FAMILY SERGESTIDAE									
Genus Acetes									
A. erythraeus	x	-	x	x	-	-	-	-	-
A. indicus	x	-	x	x	-	-	-	-	-
A. japonicus	x	-	x	x	-	-	-	-	-
A. serrulatus	x	-	x	x	-	-	-	-	-
+ A. vulgaris	-	-	x	x	-	-	-	-	-
+ A. australis	-	-	-	-	-	-	-	-	x
SECTION 2. CARIDEA FAMILY ATYIDAE									
Genus Caridina									
C. gracilipes	-	x	-	-	-	-	-	-	-
C. propinqua	-	x	x	-	-	-	-	-	-

TABLE III (cont'd)

	INDIA	PAKISTAN	MALAYSIA	SINGAPORE	CAMBODIA	PHILIPPINES	JAPAN	KOREA	AUSTRALIA
FAMILY PALAEMONIDAE									
Genus Macrobrachium									
M. nipponense	-	-	-	-	-	-	X	-	-
M. latidactylus	-	-	-	-	-	X	-	-	-
M. lanceifrons	-	-	-	-	-	X	-	-	-
M. lar	-	-	-	-	-	X	-	-	-
M. rosenbergii	-	-	X	-	-	-	-	-	-
Genus Palaemon									
+P. carcinus = Macrobrachium rosenbergii	X	X	-	-	-	-	-	-	-
+P. malcolmsonii = M. malcolmsonii	X	X	-	-	-	-	-	-	-
+P. rudis = M. rude	X	X	-	-	-	-	-	-	-
+P. idae = M. idae	X	-	-	-	-	-	-	-	-
+P. scabisculus = M. scabriculum	X	-	-	-	-	-	-	-	-
P. styliferus	-	X	-	-	-	-	-	-	-
P. paucidens	-	-	-	-	-	-	X	-	-
+P. serrifer	-	-	-	-	-	-	X	-	-
FAMILY PANDALIDAE									
Genus Pandalus									
P. borealis	-	-	-	-	-	-	-	X	-
P. hypsinotus	-	-	-	-	-	-	-	X	-

NOTE:

(a) X indicates that the species has been reported in the commercial catches of the countries under which it is shown.

(b) This table is obviously not complete because only a few countries have sent returns to the author when requested by Mr. Rosa.

(c) The names of the species given in this table are those given by the reporting countries.

(d) + indicates that the name is not listed in the List of Species of Shrimps and Prawns of economic value prepared by Holthuis and Rosa. FAO Fisheries Technical Paper No. 52. 1965. Some of these species are listed under a different genus.

6.5 Push nets

These push nets are very common in the region. They have been reported from India, Philippines, Malaysia and Singapore. Generally it consists of a bag attached to two long poles and is operated by one person who pushes the net along the sea bottom in waist-deep water. In certain countries such as Philippines and Singapore it may be operated from boats with the operator standing in the front of the boat, which is propelled along slowly so that the operator can scoop up the surface shrimps. In Singapore this net is operated at the height of the *Acetes* season. The unit stock exploited consists of species of *Penaeus*, *Metapenaeus*, *Acetes* and some Carideans. They are operated throughout the year but the catch varies with the seasons. In Singapore the net is operated throughout the year but *Acetes* spp. dominate the catch from December to April and the Metapenaeids from May to November. In the Philippines they are operated on the western side from July to December, and on the eastern side from November to May.

6.6 Cast nets

These nets are universal in the region. They have been reported from Ceylon, India, Pakistan, Philippines, Malaysia and Singapore. It is operated by a single fisherman whilst standing on a rock on the beach, or standing in waist-deep water along the shore. In Singapore it is also operated from a rowing boat (sampan), with the fisherman standing in the front part of the boat. As soon as the cast net has gone down, the boatman reverses the boat and the fisherman hauls in the net. The shrimps are caught entangled in the meshes of the net. The unit stock exploited consists of the larger Penaeids. In Singapore the operation for shrimps is normally carried out just before dawn.

6.7 Pocketed scoop nets

This method is operated in the Peel Inlet, Murray River and Swan River in Australia. It is a hand scoop net, 2 ft 6 in (76 cm) in diameter, and is used from jetties with the aid of a light to catch the school prawn *Metapenaeus mastersii* (as *M. ensis*).

6.8 Shrimp culture

Shrimp culture has been reported from four countries in the region, viz. India, Philippines, Malaysia and Singapore. An informative review on this subject has already been given by Kesteven and Job (1957). These methods have certain characteristics in common:

(a) All the methods use an enclosed body of water in which the shrimps are impounded and grow up

(b) The resources cultivated are all members of the Penaeidae

(c) The shrimps do not breed in the ponds.

The details of culture method in the different countries, however, differ. The methods in Malaysia and Singapore are similar. In this method the young shrimps are not caught and placed in the pond by the culturists. The ponds are provided with sluice gates so that at high tide the sea water together with the young shrimps is allowed to flow into the ponds. When the tide recedes, part of the water is allowed to flow out through the sluice gates. The outflowing water is filtered by wire-mesh screens in the day and by filter nets in the night. Only sufficient water is retained in the ponds for the night catching operation which consists of allowing the water in the pond to pass out through fine mesh filter nets. It is presumed that the young shrimps stay in the ponds to feed and grow up because the catches consist of shrimps which are more than 2 to 2½ in. in length. Fishing is carried out once a day during spring tides throughout the year. The shrimps are not fed and no effective fertilization of the water is carried out. The unit stock exploited consists mainly of *Penaeus* indicus, P. merguiensis, Metapenaeus mastersii (as M. ensis). Other species such as Metapenaeus brevicornis and Penaeus semisulcatus occur in fairly large numbers during certain seasons. The yield varies from 0.15 to 0.35 ton per acre per annum. With careful management the yield of 0.30 to 0.35 ton per acre per annum can be obtained. Details of this fishing method are given in the Annual Report of the Fisheries Department, Federation of Malaya and Singapore, and by Hall (1962) and Tham (1955).

In India the cultivation, as described by Gopinath (1956), is carried out in the rice fields of Travancore-Cochin. During the rice cultivation period the water is fresh or very slightly brackish. Water from the tidal backwaters is permitted to flow freely in and out of the fields after the rice harvest. In August the salinity gradually increases, as a result of the cessation of water flow from the canals and the greater influence of the tides, until March - April when it reaches a maximum. In this method young shrimps also get into the ponds through the tidal flow. They grow up in the ponds and are harvested by means of filter nets. This method of fishing ends around April. Details of this method of culture are also given by Panikkar (1956) and Menon (1955).

In the Philippines the shrimps which are cultivated in the ponds are purchased by the shrimp culturists from fishermen who specialise in catching the young of Penaeus monodon. This is the Sugpo Fry Fishery. This type of shrimp culture is normally carried out together with Chanos culture. Some of the shrimps, both Penaeus monodon and Metapenaeus monoceros, also get into the pond through the tidal inflow. Details of this method are given by Delmendo and Rabanal (1956).

From the definition of a unit fishery as given by Kesteven (1964), it is a collection of fishing units which are identifiable as a distinct group because they fish the same stock or stocks, have some common features and operate under common circumstances. In line with this definition the fishing methods for shrimps in the region can conveniently be grouped into unit fisheries exploiting the resources classified within the following framework:

(a) Freshwater

(b) Brackish water

(c) Marine

Certain fishing units such as cast nets and filter nets operate in all the three ecological divisions, particularly in the Southeast Asian sector. There is also an overlap between all these three ecological divisions in so far as distribution of shrimps are concerned. Many of the species of Penaeids are also found in both the Brackish Water and Marine divisions. In the case of Carideans some species such as Macrobrachium rosenbergii are found in both the Freshwater and Brackish Water divisions. The shrimp fauna is very mixed in each of these ecological divisions so that classification by "commodity produced" is even more unsatisfactory. The number of boat types used is also great, and many of these boat types are used even for the same fishing method so that classification by "boat types" is also unsatisfactory.

In the circumstances it is deemed that for the IPFC region as a whole the classification of unit stocks into the following ecological framework is possibly the most convenient:

(a) Freshwater

(b) Brackish water and marine inshore

(c) Marine offshore

The Shrimp Unit Fisheries of the Indo-Pacific Region may tentatively be grouped as follows:

(a) Freshwater:

- Cast nets
- Filter nets
- Seine nets
- Pocketed scoop nets

(b) Brackish water and marine inshore:

- Cast nets
- Filter nets
- Seine nets
- Push nets
- Barrier nets
- Beam trawls
- Shrimp culture

(c) Marine offshore

- Otter trawls

7 RESEARCH PROJECTS

Information on research projects on shrimps are available only from the following countries:

Malaysia	The artificial propagation of the giant freshwater prawn *Macrobrachium rosenbergii*
Korea	Studies on the fisheries biology of *Penaeus orientalis*
Philippines	Development of shrimp fisheries
	Studies on the biology of *Penaeus monodon*
Pakistan	Studies on the biology of *Palaemon malcolmsonii* (as *M.malcolmsonii*)
Australia	Gulf of Carpentaria Cooperative Prawn Survey
	Shark Bay Prawn Research Program

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A SHRIMP EXPLORATORY SURVEY IN NORTHEASTERN AND NORTHERN BRAZIL, WITH SOME BIOLOGICAL OBSERVATIONS ON Penaeus aztecus

by

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Abstract

A shrimp survey was conducted by two otter trawlers in the coastal and offshore waters of northeastern and northern Brazil from 26 June to 6 July 1965.

Data on length and weight of the brown shrimp, Penaeus aztecus Ives, were collected and regression coefficients of: (1) carapace length (first: from the tip of the rostrum to the posterior mid-dorsal edge of the carapace) on total length; (2) carapace length (second: from the base of the eye notch to the posterior mid-dorsal edge of the carapace) on total length; (3) total weight on total length; (4) tail weight on total length; and (5) tail weight on total weight were calculated. All correlation coefficients were found positive and significant ($P < 0.01$). No significant difference was found in the sex ratio.

The main species of fishes, echinoderms, molluscs and crustaceans, found in the main shrimp fishing grounds (best indicator of shrimp grounds was Squilla lijdingi Holthuis), are listed, and some observations on penaeid catches are recorded.

Good concentrations of the brown shrimp, Penaeus aztecus, were found at 20 to 40 fm depth, on muddy bottom, particularly at 1° - 3° north latitude and 48° - 49° west longitude (northern Brazil), about 100 nautical miles off the coast of Pará State and 90 nautical miles off the coast of Amapá Territory.

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CAMPAGNE DE PECHE EXPLORATOIRE DES CREVETTES DANS LE NORD-EST ET LE NORD DU BRESIL AVEC QUELQUES OBSERVATIONS BIOLOGIQUES SUR *Penaeus aztecus*

Résumé

Du 26 juin au 6 juillet 1965, deux bateaux pêchant au chalut à panneaux ont effectué une prospection dans les eaux côtières et au large des côtes nord-est et nord du Brésil.

A partir des données réunies sur la longueur et le poids de la crevette brune *Penaeus aztecus* Ives, on a calculé les coefficients de régression intéressant les rapports suivants : 1) longueur de la carapace (premièrement : de l'extrémité du rostre au bord postérieur mi-dorsal de la carapace) sur longueur totale; 2) longueur de la carapace (deuxièmement : à partir de la base de l'échancrure oculaire au bord postérieur mi-dorsal de la carapace) sur longueur totale; 3) poids total sur longueur totale; 4) poids de la queue sur longueur totale; 5) poids de la queue sur poids total. Tous les coefficients de corrélation se sont révélés positifs et significatifs ($P<0,01$). Aucune différence significative n'a été notée dans le rapport des sexes.

La communication contient une liste des principales espèces de poissons, d'échinodermes, de mollusques et de crustacés rencontrés sur les principaux terrains de pêche à la crevette (le meilleur indicateur de fonds à crevettes s'est révélé être *Squilla lijdingi* Holthuis) ainsi que quelques observations sur les prises de Penaeidés.

De bonnes concentrations de crevettes brunes, *Penaeus aztecus*, ont été trouvées par 20-40 brasses de profondeur, sur fond de vase, notamment dans la zone 1° - 3° de latitude nord et 48° - 49° de longitude ouest (Brésil du nord), à environ 100 milles nautiques au large de la côte de l'Etat de Parà et à 90 milles nautiques au large de la côte du Territoire d'Amapà.

CAMPAÑA DE PESCA EXPLORATORIA DEL CAMARON EN EL NOR-EST Y NORTE DE BRASIL CON ALGUNAS OBSERVACIONES BIOLOGICAS SOBRE *Penaeus aztecus*

Extracto

Dos barcos para la pesca de arrastre con artes de puertas realizaron un estudio camaronero en aguas costeras y de altura al noreste y norte del Brasil, del 26 de junio al 6 de julio de 1965.

Se recogieron datos sobre talla y peso del camarón, *Penaeus aztecus* Ives, y se calcularon los coeficientes de regresión de: (1) la longitud del caparazón (primero: desde la extremidad del rostro hasta el borde posterior medio-dorsal del caparazón) respecto a la talla total; (2) longitud del caparazón (segundo: desde la base de la abertura del ojo al borde posterior medio dorsal del caparazón) respecto a la talla total; (3) peso total respecto a la talla total; (4) peso de la cola respecto a la talla total; y (5) peso de la cola respecto al peso total. Todos los coeficientes de correlación hallados fueron positivos y significativos ($P<0,01$). No se observaron diferencias significativas entre machos y hembras.

Se enumeran las principales especies de peces, equinodermos, moluscos y crustáceos encontrados en los principales caladeros de camarones (el mejor indicador de bancos de camarones fue (*Squilla lijdingi* Holthuis), y se registran algunas observaciones sobre las capturas de Peneidos.

En fondos fangosos, a unas 20-40 brazas de profundidad, se hallaron buenas concentraciones de *Penaeus aztecus*, especialmente en los 1^{o} - 3^{o} de latitud norte y 48^{o}-49^{o} de longitud oeste (Brasil septentrional), a unas 100 millas naúticas de la costa del Estado de Pará y 90 millas de la costa del Territorio de Amapá.

1 INTRODUCTION

Two preliminary trawling surveys were made by an American firm based at São Luís (Maranhão, Brazil) in the coastal waters of Maranhão, at the maximum depth of 50 fm (91.4 m) (Lemos, 1956), with no success. Another shrimp and fish survey along and off the coast of northeastern and northern Brazil was made by the Japanese research vessel, TOKO-MARU, in 1956-57 (Nakamura et al., 1958). In the autumn of 1957, the U.S.A. exploratory fishing vessel, OREGON, made one cruise from Trinidad to the mouth of the Amazon River (Bullis and Thompson, 1959), and another one in 1963, from British Guiana to northeastern Brazil (Bullis, 1963).

The authors had the opportunity of making more detailed surveys aboard two commercial otter trawlers based at Fortaleza (Ceará, Brazil), for the purpose of obtaining preliminary information on the shrimp resources of coastal and offshore waters of Ceará, Piauí, Maranhão and Pará States, and Amapá Territory. Data on length and weight of a species of pink shrimp,[2] Penaeus aztecus Ives, were collected and analyzed and the main species of fishes, echinoderms, molluscs and crustaceans, found in the main shrimp fishing grounds, were identified and listed. Some general observations were made on the Penaeid catches in the area.

2 GEAR AND METHODS

The two otter trawlers aboard which the authors made the observations, DONA MARIA and GABRIEL E/ URIAS, were 65 ft (19.8 m) long, and powered by Caterpillar diesel engines of 220 hp. Their maximum speed was 8 knots. Three cotton nets were used: a small try-net of 8 ft (2.4 m) long and two large nets of 42 ft (12.8 m), all three having a mean stretched mesh size of 31 mm at the cod-end. The try-net was always operated first, and based on the quantity of shrimp caught in 20 minutes' trawling, the larger nets were cast.

Trawling operations commenced on 26 June, and terminated on 6 July 1965.

The data obtained during the surveys made by the two boats are shown in Fig. 1 and Tables I and II. The try-net operations from the otter trawler, GABRIEL E. URIAS, were not recorded.

Soon after hauling the nets, one or more specimens of every species were fixed in formalin, for further identification at the laboratory. When the haul yielded less than 100 specimens of P. aztecus, the whole shrimp catch was used as a sample. In cases of larger catches, 100 specimens were picked up at random and all measured and weighed aboard.

The data collected from each shrimp specimen were the following:

(i) total length in mm, from the tip of the rostrum to the posterior end of the telson, with the shrimp slightly extended on a ruler

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2/ In Brazil P. aztecus is known as "camarão rosa" (pink shrimp) (Ed.)

E/1

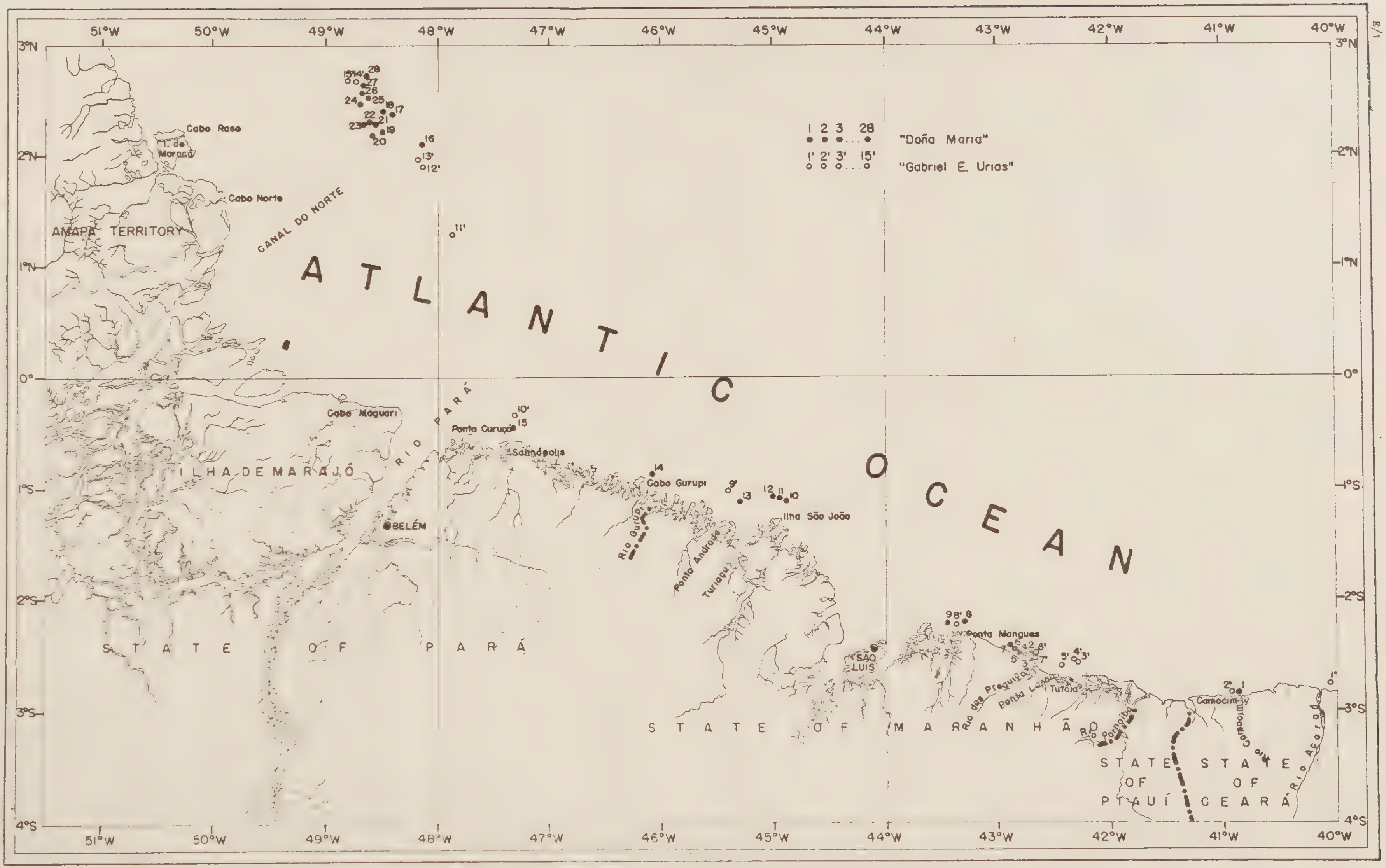

Fig. 1 Approximate position of the trawl stations made by DONA MARIA and GABRIEL E. URIAS in the coastal and offshore waters of northeastern and northern Brazil.

TABLE I

Characteristics of the survey stations and catches of the otter trawler DONA MARIA

Date (1965)	Station no.	Survey area	Trawling time (h)	Distance from coast (nautical miles)	Depth (fm)	Nature of the bottom	Catch (total weight in kg)	
							Fish	Shrimp
26 June	1	Camocim	0.20	3	9	sandy shell	0.40	-.-
27 June	2	Rio Preguiças	0.20	2	6	sandy shell	0.50	-.-
27 June	3	Rio Preguiças	0.20	1	4	sandy shell	0.50	0.05
27 June	4	Rio Preguiças	0.20	1	4	sandy shell	-.-	0.04
27 June	5	Rio Preguiças	0.20	1	4	sandy shell	0.80	-.-
27 June	6	Rio Preguiças	0.20	1	4	sandy shell	1.00	0.10
27 June	7	Rio Preguiças	0.20	1	4	sandy shell	0.50	0.04
27 June	8	Ponta Mangues	0.20	6	6	sand	-.-	-.-
27 June	9	Ponta Mangues	0.20	6	6	sand	-.-	0.10
29 June	10	Ilha São João	0.20	7	10	sand	0.20	0.44
29 June	11	Ilha São João	0.20	7	10	sand	0.10	0.82
29 June	12	Ilha São João	0.20*	7	10	sand	5.00	-.-
29 June	13	Ponta Andrade	2.00*	10	10	sand	100.00	4.00
30 June	14	Cabo Gurupi	0.20	6	10	mud	0.10	0.05
1 July	15	Salinópolis	0.20	5	10	mud	0.20	0.04
3 July	16	Canal do Norte	0.20	95	30	sandy shell	0.30	-.-
3 July	17	Cabo Maguari	0.35	100	40	mud	0.20	0.15
3 July	18	Cabo Maguari	0.30	100	40	mud	0.10	0.10
4 July	19	Cabo Maguari	0.30	100	30	mud	0.10	0.29
4 July	20	Cabo Maguari	0.20	100	20	mud	0.15	0.43
4 July	21	Cabo Maguari	0.20	100	23	mud	0.30	-.-
4 July	22	Cabo Maguari	2.00*	100	23	mud	100.00	1.15
4 July	23	Cabo Maguari	0.20	100	23	mud	0.10	0.02
4 July	24	Cabo Raso	4.10*	89	30	mud	50.00	70.00
4/5 July	25	Cabo Raso	4.00*	89	40	mud	100.00	90.00
5 July	26	Cabo Raso	4.00*	89	40	mud	150.00	80.00
5 July	27	Cabo Raso	4.00*	89	40	mud	30.00	90.00
6 July	28	Cabo Raso	5.00*	89	40	mud	50.00	60.00

*Large nets; the rest, try-net

TABLE II

Characteristics of the survey stations and catches of the otter trawler GABRIEL E. URIAS

Date (1965)	Station no. *	Survey area	Trawling time (h)	Distance from coast (nautical miles)	Depth (fm)	Nature of the bottom	Catch (total weight in kg)	
							Fish	Shrimp
26 June	1'	Acaraú	0.20	5	3	sand	0.10	-.-
26 June	2'	Camocim	0.25	3	2	sandy shell	0.06	-.-
27 June	3'	Tutóia	0.20	13	16	sand	1.00	-.-
27 June	4'	Tutóia	0.20	13	16	sand	1.00	-.-
27 June	5'	Ponta Lazou	0.20	10	9	sand	3.00	0.20
27 June	6'	Rio Preguiças	0.15	3	5	mud	1.00	0.03
27 June	7'	Rio Preguiças	0.20	2	4	sand and mud	2.00	-.-
28 June	8'	Ponta Mangues	0.20	8	8	sand	3.00	-.-
29 June	9'	Ponta Andrade	3.00**	15	6	sand and mud	1.00	0.10
30 June	10'	Salinópolis	0.15	15	7	sand and mud	0.30	0.20
2 July	11'	Ponta Curuçá	0.30	90	25	rocks	0.10	0.15
4 July	12'	Cabo Maguari	2.00**	100	30	mud	30.00	50.00
4 July	13'	Cabo Maguari	4.00**	100	30	mud	80.00	70.00
5 July	14'	Cabo Raso	4.00**	89	40	mud	40.00	50.00
6 July	15'	Cabo Raso	5.00**	89	40	mud	35.00	60.00

* Several try-net operations were not recorded

** Large nets; the rest, try-net

(ii) carapace length in mm (a) from the tip of the rostrum to the posterior mid-dorsal edge of the carapace, and (b) from the base of the eye notch to the posterior or mid-dorsal edge of the carapace

(iii) sex

(iv) total weight to the nearest tenth of a gram

(v) tail weight to the nearest tenth of a gram

3 ANALYSIS OF THE DATA

3.1 Length and weight of the pink shrimp

The analyses of biometrical data are shown in Table III. Data on total length were grouped into 5 mm intervals, and total weight into 2.5 g intervals.

Regression coefficients of carapace length (first case: from the tip of the rostrum to the posterior mid-dorsal edge of the carapace) on total length were based on 270 males and 296 females. In this case, significant difference was found between sexes. The equations are:

$$\text{males:} \quad Y = -\ 0.77 + 0.37X \ (r = 0.99)$$

$$\text{females:} \quad Y = -\ 3.31 + 0.41X \ (r = 1.00)$$

where X is the total length and Y is the carapace length, both in mm.

Regression coefficients of carapace length (from the base of the eye notch to the posterior mid-dorsal edge of the carapace) on total length were calculated based on 52 males and 44 females. No significant difference was found between sexes, the equation being:

$$Y = -12.00 + 0.32X \ (r = 1.00)$$

where X is the total length and Y the carapace length, both in mm.

Regression coefficients of total weight on total length were calculated by least squares of a logarithmic transformation, using data on 268 males and 295 females. No significant difference was found between sexes, the equation being:

$$\log W = -\ 5.356 + 3.124 \log L \ (r = 1.00)$$

where W is the total weight in grams and L the total length in mm (Fig. 2).

Regression coefficients of tail weight on total length were calculated by least squares of a logarithmic transformation, based on 61 males and 39 females. Significant difference was found between sexes. The equations are:

TABLE III

Data concerning the proportional measurements of length (mm) and weight (g) of the pink shrimp, *Penaeus aztecus*, sampled during June–July 1965, along and off the coast of northeastern and northern Brazil

Proportional measurements	Number of specimens		Maximum value		Minimum value		Arithmetic mean		Standard deviation		Coefficient of variation	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Total length (1)	270	296	158.00	193.00	83.00	73.00	126.74	161.51	13.76	25.29	10.86	15.66
Total length (2)	52	44	173.00	188.00	113.00	128.00	134.44	157.20	12.90	15.01	9.60	9.55
Total length (3)	268	295	158.00	193.00	83.00	73.00	126.92	149.47	13.64	24.69	10.75	16.52
Total length (4)	61	39	153.00	193.00	108.00	143.00	136.44	165.69	9.93	14.81	7.28	8.94
Carapace length (5)	270	296	60.00	76.40	31.50	28.00	47.47	57.90	12.26	9.83	25.83	16.98
Carapace length (6)	52	44	43.00	48.00	25.00	28.00	30.80	38.53	3.91	4.26	12.69	11.06
Total weight (7)	268	295	29.50	62.60	4.00	3.00	16.24	46.28	4.88	13.86	30.05	29.95
Total weight (8)	61	39	31.00	66.00	8.50	21.00	19.52	39.65	4.68	11.68	23.98	29.46
Tail weight (9)	61	39	19.00	40.00	6.00	14.30	12.59	24.11	2.79	6.93	22.16	28.74
Tail weight (10)	61	39	17.30	38.30	6.00	14.70	12.57	23.99	1.65	6.64	12.57	27.68

(1) Used for obtaining the regression coefficients of carapace length (5) on total length
(2) Used for obtaining the regression coefficients of carapace length (6) on total length
(3) Used for obtaining the regression coefficients of total weight (7) on total length
(4) Used for obtaining the regression coefficients of tail weight (10) on total length
(5) From the tip of the rostrum to the posterior mid-dorsal edge of the carapace
(6) From the base of the eye notch to the posterior mid-dorsal edge of the carapace
(7) Used for obtaining the regression coefficients of total weight on total length (3)
(8) and (9) Used for obtaining the regression coefficients of tail weight on total weight
(10) Used for obtaining the regression coefficients of tail weight on total weight (4)

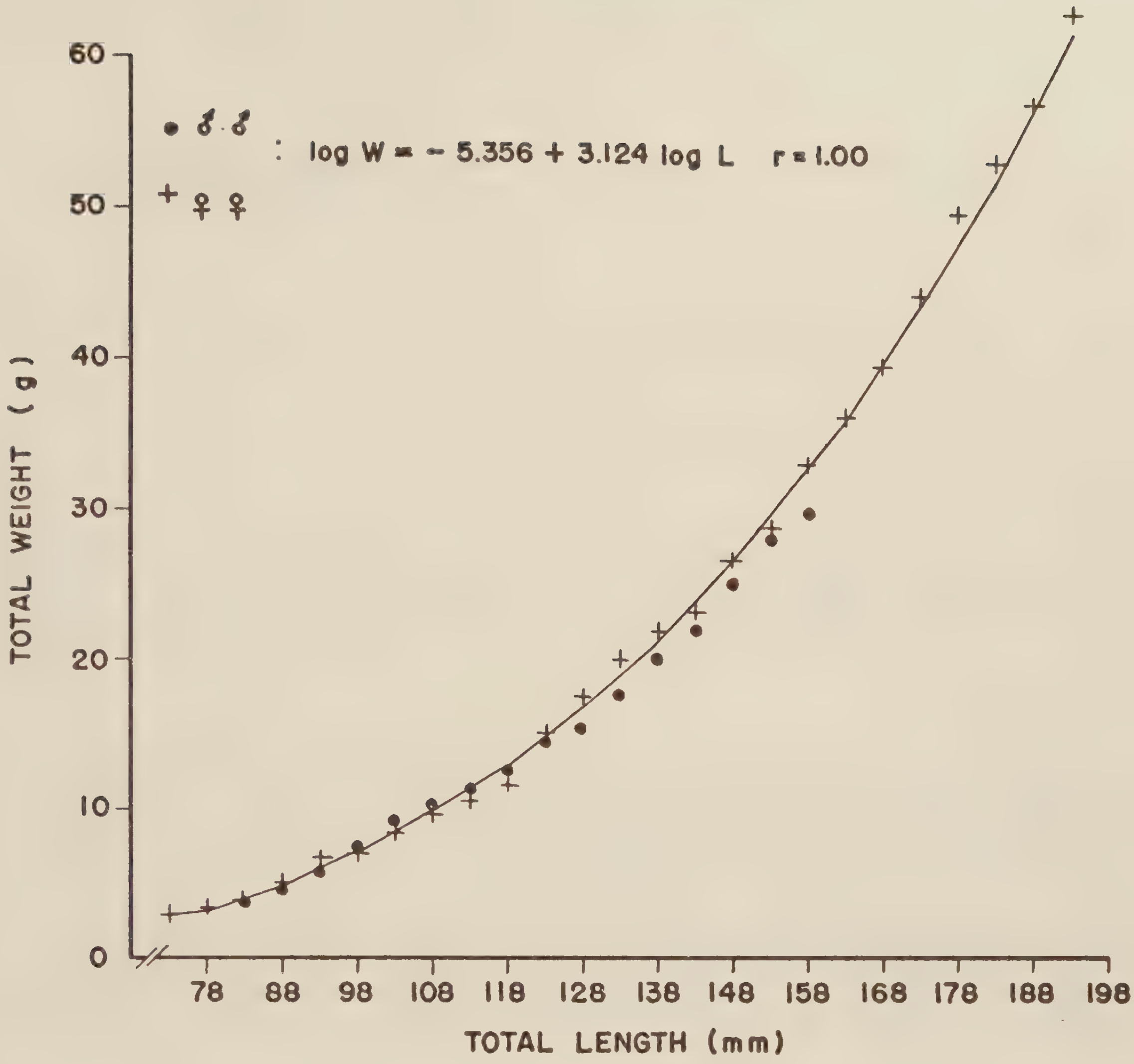

Fig. 2 Regression of total weight on total length of the pink shrimp, *Penaeus aztecus*.

$$\text{males:} \quad \log W = -5.617 + 3.143 \log L \ (r = 1.00)$$

$$\text{females:} \quad \log W = -4.759 + 2.762 \log L \ (r = 1.00)$$

where W is the tail weight in grams and L the total length in mm.

Regression coefficients of tail weight on total weight were calculated using data on 61 males and 39 females. Significant difference was found between sexes. The equations are:

$$\text{males:} \quad Y = 0.96 + 0.59X \ (r = 0.99)$$

$$\text{females:} \quad Y = 0.71 + 0.59X \ (r = 0.99)$$

where X is the total weight and Y the tail weight, both in grams.

3.2 Sex ratio

The total number of specimens sexed was 566, of which 270 were males (47.7 percent) and 296 females (52.3 percent). Chi-square test ($\chi^2 = 1.18$; $P > 0.05$) showed that there is no significant difference in sex ratio from the expected ratio of 1:1.

3.3 Accompanying fauna

During the entire survey, 65 species of fishes were recorded in the catches. The most abundant species were: shark, Scoliodon terrae-novae Richardson; guitarfish, Rhinobatus percellens (Walbaum); rays, Gymnura micrura (Bloch and Schneider), Dasyatis gymnura (Müller) and Urotrygon microphthalmum Delsman; catfish, Felichthys bagre (Linnaeus) and Galeichthys sp.; moray eels, Ariosoma nitens? (Jordan and Bollman), Ophichthus magnioculis (Kaup), Gymnothorax ocellatus Agassiz and Gymnothorax jordani (Evermann and Marsh); goatfish, Prionotus caprella? (Ribeiro); lane snapper, Lutianus synagris (Linnaeus); grunt, Conodon nobilis (Linnaeus); soles, Scyacium latifrons? (Jordan and Gilbert), Achirus fasciatus (Lacépède), Achirus sp. and Symphurus elongatus? (Günther).

Nine species of echinoderms were recorded during the survey and of these, three, Luidia senegalensis (Lamarck), Astropecten marginatus Gray; and the brittlestar, Ophioderma sp. were the most abundant.

Twenty species of molluscs were recorded during the survey of which only one, the scallop, Amusium papyraceus Gabb, occurred in any number in the main shrimp fishing grounds.

Thirty-seven species of crustaceans were recorded of which only five were abundant, viz: the shovel-nosed lobster, Scyllarides delfosi Holthuis; crabs, Calappa nitida Holthuis, Calappa sulcata Rathbun and Callinectes danae Smith; and the mantis shrimp, Squilla lijdingi Holthuis. This last species was found to be the best indicator of shrimp grounds. Among the Penaeidae, seven species were recorded in the following order of importance: pink shrimp, Penaeus aztecus; sea bob shrimp, Xiphopenaeus kroyeri (Heller); white shrimp, Penaeus schmitti Burkenroad; Solenocera geijskesi? Holthuis; rock shrimps, Sicyonia typica (Boeck) and Sicyonia dorsalis Kingsley; and Trachypenaeus constrictus (Stimpson).

4 DISCUSSION

4.1 Penaeid catches

Young and medium-sized pink shrimp, P. aztecus, were caught in coastal waters of Maranhão and Pará States (station nos. 3, 6, 7, 9, 13, 15 and 5', 6', 10'), but not in large quantities. According to observations of Coelho (1963), this species is abundant in the catches of stop seines and trap nets in estuaries and along the beaches of Maranhão State. Large ones were caught only in offshore waters of Pará State and Amapá Territory (station nos. 17/28 and 11'/15'), at 20 to 40 fm (37 to 73 m) depth, on muddy bottom. Lemos (1956) was of the opinion that surveys should be made at 150 to 200 fm (274 to 366 m) depth because adult shrimps inhabit deep waters. No opportunity to trawl at these depths was given, but large shrimps were taken by us at 40 fm depth, off Pará State and Amapá Territory. Holthuis (1959) also states that adult specimens of pink shrimp are, as a rule, found farther offshore (12 to 30 fm (22 to 55 m) depth). In offshore waters of Maranhão State, however, the bottom at over 22 fm (40 m) depth is composed of corals, and is not suitable for trawling (Nakamura et al., 1958).

The TOKO-MARU report (Nakamura et al., 1958) recommends shrimp fishing in the coastal zone of Maranhão State. In waters south of Pará River, the above research vessel made only five trawling stations over a small flat zone, of 10 to 16 fm (18 to 29 m) depth, and it was observed that the muddy zone, north of Pará River, must be more promising fishing ground than the southern zone.

It is reported (Anon, 1953) that offshore waters from the Amazon River to Recife (Pernambuco) yield heavy catches of large shrimp from June through September, but the scientific names of the species are not given.

Lindner (1957) states that about 60 percent of the catch in the area between Marajó Bay and São Luís, and in the area around Parnaíba appear to be sea bobs, while the young of P. schmitti and of P. aztecus together constitute 40 percent. According to the same author, shrimps are caught throughout the year in northern waters. Coelho (1963) states that in the coastal waters of Maranhão State the best period of shrimp fishing is from April to August, after the rainy season.

In the neighbourhood of the area surveyed, where P. aztecus was taken (latitudes 1° to 3° N and longitudes 48° to 49°W), the exploratory fishing vessel OREGON made sporadic catches of that species in the autumn of 1957 (Bullis and Thompson, 1959). Pink shrimps were taken in depths from 10 to 50 fm (18 to 91 m), but beyond 40 fm (73 m) the quantity caught was considerably less, occurring more frequently in the 25 to 30 fm (46 to 55 m) range along with Penaeus brasiliensis Latreille. However, in our samples of shrimp catches from this region and made at 20 to 40 fm (37 to 73 m) depth, we did not find any P. brasiliensis but only P. aztecus. Both vessels as well as the OREGON found them predominantly on muddy bottoms, the best catches of the latter amounting to 30 to 45 lb (13.6 to 20.4 kg) per h (heads-on).

During the present survey, 28 boats were sighted operating in the area, confirming the statement of Richardson (1962) that foreign-based shrimp boats were fishing off the mouth of the Amazon River. One of the 28 boats, GULF KING III, from Barbados, caught an average of 1,000 lb (454 kg) (heads-off) per night's fishing (12 h), equivalent to about 83 lb (37.6 kg) (heads-off) per h, much more than recorded by OREGON. Our vessel, DONA MARIA, caught only about 280 lb (127 kg) (heads-off) from sundown of 4 July to dawn of 5 July 1965 (12 h), equivalent to about 23.3 lb (10.6 kg) (heads-off) per h. We noticed that the fishermen of our boats were not so skilled as the ones from Barbados.

As to the white shrimp, P. schmitti, only six large specimens were caught at 3 to 7 fm (5.5 to 12.8 m) depth, in the coastal waters of Maranhão State (station nos. 4, 11, 13 and 9'), alone or mixed with medium-sized pink shrimp, P. aztecus.

Large-sized specimens of white shrimp are commonly caught in estuaries and beaches of Maranhão coast (Coelho, 1963), but due to the few stations made in the present survey, it is not possible to state whether white shrimp is, or not, abundant in offshore waters.

Small quantities of sea bob were caught at station nos. 14, 15, 10' (inshore waters of Maranhão and Pará States), and 11' (offshore waters of Pará State).

One specimen of Sicyonia typica was found at station no. 26, and three of Solenocera geijskesi? at station no. 13', both mixed with P. aztecus; one specimen of Sicyonia dorsalis, and one specimen of Trachypenaeus constrictus, at station no. 10', both mixed with P. aztecus, schmitti and X. kroyeri.

4.2 Proportional measurements of the pink shrimp

Correlation coefficients of all the measurements studied are positive and significant ($P<0.01$). Of the regression coefficients of carapace length on total length, the second one, where carapace length is measured from the base of the eye notch to the posterior mid-dorsal edge of the carapace, showed no significant difference between sexes, while the first, where carapace length is measured from the tip of the rostrum to the posterior mid-dorsal edge of the carapace, presented significant difference.

These proportional measurements being closely correlated, it is possible to designate sizes by carapace length (from base of eye notch to posterior mid-dorsal edge of carapace) and convert it easily into total length, total weight and tail weight, by making use of those regression coefficients.

5 CONCLUSIONS

The main purpose of the survey was to obtain information on the shrimp resources of northeastern and northern Brazil. In northern Brazil good concentrations of the pink shrimp were found in July 1965 at 20 to 40 fm (37 to 73 m) depth, on muddy bottom, particularly at latitudes 1° to 3°N and longitudes 48° to 49°W, about 100 nautical miles off the coast of Pará State and 90 nautical miles off the coast of Amapá Territory. In northeastern Brazil the offshore waters are not rich in shrimp resources, at any rate in the area surveyed.

The best indicator of shrimp grounds was found to be mantis shrimp, _Squilla lijdingi_.

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BIOLOGY OF POTENTIALLY VALUABLE FRESH-WATER PRAWNS WITH SPECIAL REFERENCE TO THE RICELAND PRAWN *Cryphiops* (*Macrobrachium*) *lanchesteri* (de Man)

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Abstract

Only one species of fresh-water prawn, *Cryphiops* (*Macrobrachium*) *rosenbergii* (de Man), is at present exploited on any considerable scale in Malaysia. A species of potential value is *Cryphiops* (*Macrobrachium*) *lanchesteri* (de Man), despite its relatively small size. Favourable features include: the large numbers in which it may occur; its ability to reproduce in standing fresh waters; its pronounced eurytopy; and its apparently vegetarian habits. Given suitable environmental conditions, it would be a suitable species for pond culture.

BIOLOGIE DE CERTAINES CREVETTES D'EAU DOUCE SUSCEPTIBLES DE PRESENTER UN INTERET COMMERCIAL, NOTAMMENT LA CREVETTE DES RIZIERES *Cryphiops* (*Macrobrachium*) *lanchesteri* (de Man)

Résumé

Actuellement, une seule espèce de crevette d'eau douce, *Cryphiops* (*Macrobrachium*) *rosenbergii* (de Man) est exploitée de manière assez étendue en Malaisie. Une autre espèce qui pourrait se révéler intéressante malgré sa petite taille est *Cryphiops* (*Macrobrachium*) *lanchesteri* (de Man). Les caractéristiques favorables de cette espèce comprennent notamment : son abondance relative; son aptitude à se reproduire en eau douce stagnante; son eurytopie prononcée; enfin, ses habitudes apparemment végétariennes. Dans des conditions de milieu appropriées cette espèce devrait convenir à l'élevage en étang.

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BIOLOGIA DE LANGOSTINOS DE AGUA DULCE POTENCIALMENTE VALIOSOS CON ESPECIAL REFERENCIA AL LANGOSTINO *Cryphiops* (*Macrobrachium*) *lanchesteri* (de Man)

Extracto

Sólo una especie de langostino de agua dulce, *Cryphiops* (*Macrobrachium*) *rosenbergii* (de Man), se explota actualmente en escala algo considerable en Malasia. A pesar de su tamaño relativamente pequeño, una especie de valor potencial es *Cryphiops* (*Macrobrachium*) *lanchesteri* (de Man). Sus características favorables incluyen: las grandes cantidades en que existen; capacidad para reproducirse en aguas dulces inmóviles; su destacada euritopía; y sus aparentes costumbres vegetarianas. En condiciones ambientales favorables sería una especie adecuada para su cultivo en estanques.

1 INTRODUCTION

In Malaya[1] prawns form an important element in the fauna of most fresh-water habitats though they are absent from many isolated ponds, some streams and rivers in high mountains, and moderately to highly polluted waters. Their abundance, their role in the ecology of fresh-water habitats and their high protein content give them considerable potential importance.

Lanchester (1901) reported a few species of prawns collected by the Skeat expedition. He also collected several species at Singapore in 1899 but made no report on these. They have been examined by Johnson (1962a) together with specimens collected by Flower. Roux (1935; 1936) deals with two species of fresh-water prawns. In recent years the author has been carrying out a program of taxonomical and distributional studies. The results have been published in a series of papers (Johnson, 1960a, 1960b, 1961, 1962a, 1962b, 1964). The relation between distribution of several species and various physical and chemical factors is discussed by Johnson (1967b). Two recent papers (Johnson 1966 and Johnson (in press)) attempt to assess their potential value as food organisms.

The only Malaysian species which is at present exploited on any considerable scale is the udang galah, Cryphiops (Macrobrachium) rosenbergii (de Man). This species, the largest of the oriental fresh-water prawns, is popular in Malaysia, though not in Singapore, and available supplies are scarcely sufficient to meet the demand. The Malaysian Fisheries Department instituted a program of research, which is chiefly concerned with developmental requirements and other problems involved in large-scale culture of this prawn (Ling, 1962; Ling and Merican, 1961). The larvae can now be reared on a large scale in low salinity water and the young prawns used for stocking isolated fresh-water ponds. The carnivorous and cannibalistic tendencies of this species, however, limit its usefulness for pond culture.

One justification, though by no means the only one, for pursuing general research on Malaysian fresh-water prawns, is the possibility that one or more hitherto unexploited or under-exploited species may prove to possess potential economic value. The present paper is an attempt to summarize some of this research carried out with limited facilities, as a part-time study. It does not purport to be a final report, but is intended rather as a pointer to possible further research.

2 SPECIES OF POTENTIAL ECONOMIC VALUE

Amongst the fresh-water prawns considered of economic importance by Holthuis and Rosa (1965), they list several species as occurring in the area 433 (Malaysia, Singapore, Cocos and Keeling Islands). Johnson (in press) has given detailed comments on these. Caridina gracilirostris de Man is specifically indicated as being cultured in area 433, whereas it is not exploited at all. Of the species which they list, the only one that is currently exploited in Malaya on any noteworthy scale is Cryphiops (Macrobrachium) rosenbergii. Atya spinipes Newport is the object of a very small-scale subsistence fishery in a few areas.

It is possible that the small atyid prawns, such as Caridina gracilirostris, C. propinqua de Man, and C. tonkinensis Bouvier (not mentioned by Holthuis and Rosa), which occur in low salinity brackish waters, could form the basis of a culture fishery which might be especially attractive as a means of utilizing the productivity of waters which are now neglected. The more typically fresh-water species of this genus are distinctly local in Malaysia and sporadic in occurrence. In combination with their small size these distributional features suggest that they are not the most suitable species for exploitation in Malaysia, though pond culture of C. simoni peninsularis Kemp should be feasible.

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[1] To be considered for the purpose of this paper as comprising western Malaysia and the Republic of Singapore

The two commonest prawns of the tree country of southern Malaya are Cryphiops (Macrobrachium) geron (Holthuis) and C. (M). trompi (de Man)(not listed by Holthuis and Rosa (1965)). Both may be abundant in forest streams and rivers; both have excellent flavour. But the waters of their natural habitats tend to be unproductive so it is unlikely that either will ever be exploited on a large scale.

Of the remaining species only two, C. (M). lanchesteri, the riceland prawn, and C. (M). sintangensis (de Man) appear to have potential economic value on present evidence. The former is more likely to prove important. Though it is somewhat the smaller it is more widespread, often more abundant where it occurs, and more commonly found in ponds and ditches.

3 Cryphiops (Macrobrachium) lanchesteri

3.1 General considerations

C. (M). lanchesteri is a relatively small species but one which may make a considerable contribution to the biomass of the habitat in which it lives since it normally occurs in large numbers. A good swimmer, it is less strictly a bottom dweller than are many palaemonids. It has a light and somewhat compressed build and a relatively large abdomen and lives in fresh waters throughout its life cycle. The species appears to be indigenous to the swamps and ricelands of southeast Asia from where it appears to have penetrated south along the Malay peninsula. It has reached Singapore, probably through human agency, but has not yet been recorded in Indonesian waters.

Johnson (1964) mapped the Malaysian distribution of this species, but a number of new records have subsequently been added. It is now known to occur in the ricelands of central Trengannu and near Kuala Sedili Besar in eastern Johore. It probably occurs generally in riceland areas, and in the numerous fish ponds, slow rivers, streams, canals, many ditches, and in inundated disused mines.

3.2 Size

In the Malaysian area ovigerous females of C. (M). lanchesteri may have an overall length of only 33 mm. Wild caught specimens seldom exceed 50 mm but the author obtained larger specimens from the research ponds of the Tropical Fish Culture Research Station at Batu Berendam, Malacca. The largest, a male, had an overall length of 62 mm. The large-sized males differ somewhat from the smaller individuals previously described and will necessitate a redescription of the species. In these ponds the pH, calcium content, and phosphate content of the water tend to be higher than in many natural habitats, and there is an abundant supply of digestible algae; but even where these conditions prevail in natural habitats such large individuals have not been obtained. A probable contributory factor is the rarity of efficient predatory fish which are excluded and eliminated in the ponds. It is quite likely that in uncontrolled habitats prawns do not survive long enough to attain the maximum size.

3.3 Water

As stated earlier, *C.(M). lanchesteri* flourishes in standing and slowly flowing waters. Zoeae and post-larvae can sometimes be obtained from isolated pond habitats, and populations in such habitats appear to maintain themselves. It thus seems clear that breeding as well as growth may occur in stagnant water. Nonetheless populations can become established in streams with a moderate water flow if other conditions are favourable. The maximum flow which the author has recorded for such a habitat was 0.70m/sec.

3.4 Temperature

Since *C.(M). lanchesteri* can live in shallow habitats it has to be able to withstand exposure to rather high temperatures for periods of several hours. The full range of temperatures from which the species has been collected is 25.5°C to 36.0°C, which corresponds to the temperature range of aquatic habitats in southern Malaya. Presumably it occurs at somewhat lower winter temperatures of countries to the north of Malaysia. It would be interesting to know the high temperature tolerance of the species in these countries since Malaysian specimens appear to be killed by slightly higher temperatures.

C.(M). lanchesteri does not appear to exhibit any behavioural response to increasing temperature. Thus during 1965 the author has observed that, at the Sembawang hot springs, Singapore, individual prawns continued to move undisturbed into water with temperature above 40°C though fishes turned back. The stretch of stream with temperatures between 40° and 45°C had the bottom littered with dead prawns. Similarly in open streams, in the middle of the day, the fish tend to congregate under bridges or in deep holes where the water temperature may be as much as 2°C below that of the rest of the stream; the prawns, by contrast, remain generally distributed.

Though no critical experiments have been carried out it appears from observations in hot springs that continued exposure to temperatures above 40°C is lethal to *C.(M). lanchesteri*. The upper safety margin is thus very small with the species flourishing in habitats in which the highest temperatures are only slightly below the lethal. However, throughout the Malaysian area temperatures of fresh waters seldom rise above 36°C and never above 37.5°C so that the hazard of high temperature death is more apparent than real. Nothing is known of lower temperature limits, but since the species occurs in more seasonal climates than in Malaysia it is unlikely that any such limitation by low temperature will be operative in the Malaysian area.

3.5 Oxygen

Water oxygen determinations from 45 habitats of *C.(M). lanchesteri* yielded a saturation range from 1 to 148 percent. About 13.3 percent of the habitats had less than 25 percent oxygen saturation. All readings were taken during daylight at least 3 h after sunrise. The present observations indicate that *C.(M). lanchesteri* is more tolerant to low oxygen than are other Malaysian prawns. It is the only species which has been collected from a habitat with less than 10 percent oxygen saturation. It should be noted, however, that it has never been collected from any habitat with oxygen so low as to be undetectable by the ordinary Winkler method.

3.6 Pollution

Like other prawns, C.(M). lanchesteri appears to be unable to withstand any marked degree of organic pollution though it is not clear just which factors are deleterious. Low oxygen content might be operative in some habitats but the species is absent even where the oxygen content is apparently high. Intolerance to high concentrations of ammonia is another possible limiting factor. No records from habitats with ammonia concentrations greater than 4 ppm are available.

Though there is no precise information it is probable that this species is more tolerant to tin mine pollution than are most species, as evidenced by its common occurrence in mine pools and pools in tin tailings.

3.7 Salinity

While abundant in fresh waters C.(M). lanchesteri seldom occurs in estuarine waters. However, in the absence of experimental evidence one cannot rule out the possibility that it is euryhaline, being excluded from more saline waters by biotic factors. Whatever the reason, this inability to penetrate high salinity waters is important in restricting its natural distribution, and has probably prevented it from spreading to Indonesia. Though it is present on Penang and Singapore islands, it has not been found on other small islands in the area.

It has been stated earlier that all developmental stages of this prawn can thrive in fully fresh-water habitats. It occurs in a reservoir near Malacca where the salinity (Hutchinson, 1957) is only 5.91 ppm, and it thrives in riceland streams in the same area with salinities between 10.0 and 20.0 ppm.

Tolerance to chloride ion concentration is related to the general problem of salinity tolerance. In the ionically well balanced waters of the Sembawang hot springs the chloride ion concentration was 9.504 mEq/l [2], corresponding to a chlorinity of 0.97 parts per thousand. The species can survive in ionically well balanced waters when the chloride ion is as little as 0.036 mEq/l. C.(M). lanchesteri is absent in highly acid waters with a pronounced anion excess even if the chloride content is optimum, as observed in an irrigation canal at Klebang Besar near Malacca, which had a chloride concentration of 1.636 mEq/l, pH of 4.8 and an anion excess of 1.647 mEq/l.

The recorded limits for sodium concentration cover much the same range as those for chloride but with both lower and upper limits slightly higher, from 0.076 to 10.65 mEq/l. The ability of this and other Malaysian fresh-water prawns to survive in waters which are very poor in chloride and sodium is especially noteworthy.

3.8 Other chemical factors

C.(M). lanchesteri appears to be a eurytopic species capable of thriving under a wide variety of chemical conditions, though it is perhaps less adapted to acid waters than are such species as C.(M). trompii. It is most frequently found in waters with pH between 6.0 and 7.0 and there are no records from waters with pH below 4.9. Johnson (1967b) gives 7.6 as the upper limit but it has since been found that the species can survive in habitats where the daytime pH may exceed 9.0. The rarity of such records merely reflects the rarity of freshwaters with pH exceeding 7.5 in southern Malaya.

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[2] milli-equivalent

The records for alkalinity give a similar picture to those for pH, the mean value of 46 records being 0.460 mEq/l. There are few records from localities with alkalinity below 0.150 mEq/l and the lowest alkalinity from which the species has been recorded is 0.080 mEq/l. Thus though C. (M). lanchesteri occurs in soft waters it does not extend into the extremely soft waters common in southern Malaya. It does, however, occur in habitats with alkalinities up to 2.80 mEq/l. It is absent in waters in which there is a considerable absolute anion excess.

Chloride ion concentration has already been considered under section 3.7. The limited records for sulphate ion concentrations are mostly from waters which are poor in sulphate with concentrations ranging from about 0.001 to 0.268 mEq/l. The exception was at the Sembawang hot springs where the sulphate concentration is as high as 1.58 mEq/l. Thus C. (M). lanchesteri can tolerate moderately high sulphate concentrations in waters which are ionically well balanced. Its absence from acid sulphate waters may well be due to the marked anion excess and consequent low pH of these waters. The ability to survive in habitats where there are only traces of sulphate ion is especially noteworthy in view of the widespread occurrence of such waters in many tropical areas.

Almost all southern Malayan waters are poor in calcium (Johnson, 1967 a). The author has recorded C. (M). lanchesteri from waters with calcium content ranging from 0.000 to 0.287 mEq/l. It is fairly certain that there are localities in northern and central Malaya in which C. (M). lanchesteri occurs in waters of higher calcium concentrations. According to the classification of Ohle (1934) as modified by Williams (1964) all these habitats are poor in calcium. However it is as well to note that many C. (M). lanchesteri habitats have biota of a type which in other countries would indicate calcium-rich waters, even though chemical determinations show the waters to be calcium-poor. Thus in Lake Chenderoh in Perak, snails and bivalves are very abundant, yet, according to the analysis kindly provided by J.W. Wood, Chief Chemist of the Perak River Hydro-Electric Power Company Ltd., the calcium content in August 1964 was only 0.160 mEq/l. The capacity of this prawn (and such other species as C. (M). trompii) to survive in habitats with calcium concentrations of less than 1 part in 100,000,000 is remarkable in view of the physiological requirements of decapod crustaceans. Concentrations of magnesium appear to be parallel to those of calcium, but the species has not been found in habitats devoid of magnesium. It is also absent from the magnesium rich gelam-type waters of the Malacca area, with pronounced anion excess and very low pH. Sodium contents of the habitats have already been discussed in section 3.7. In most Malayan habitats sodium is found to be in excess of calcium whatever the absolute concentrations. Recorded potassium concentrations of waters where the species occurs range from 0.005 to 0.707 mEq/l.

3.9 Food

At present there is little precise information on the food of this and most other Malaysian fresh-water prawns. Observations on food are especially difficult for palaemonid prawns because of their small size, the delicate structure of the proventriculus and the extremely finely comminuted nature of its contents that makes identification often impossible. Observations on gut contents must, therefore, be supplemented by observations on feeding under natural conditions.

Most of the larger fresh-water palaemonids appear to be to some extent carnivorous as is C. (M). rosenbergii but the carnivorous tendencies are less marked or absent in many smaller species. There is no evidence of predation or cannibalism in C. (M). lanchesteri. It does not feed on higher plants nor on large pieces of vegetable detritus. The few observations on its feeding, and on the contents of its proventriculus (algal remains and chlorophyll), suggest that it is an algal feeder.

4 GENERAL DISCUSSION

It will be clear from the above that our knowledge of the biology of Malaysian fresh-water prawns is still inadequate. We know fairly well which species occur and something of the conditions under which they live. From such data we can presume the possible limiting factors. For most species we know very little about food and reproduction and nothing of important physiological features, longevity, and growth rates. There is hardly any information on the standing stock of any species.

Nonetheless what is known is sufficient to suggest possible productive lines of investigation. Little attempt has been made to exploit these fresh-water prawns with the exception of C.(M). rosenbergii. That species is valuable because of its large size and good flavour but it has several disadvantages. The early larval stages require brackish water; the adults are at least partially carnivorous and also cannibalistic. Only a few of the remaining species occur in productive waters in sufficient abundance to suggest that they could form the basis of a possible prawn fishery or pond culture industry. Of these the riceland prawn, C.(M). lanchesteri, appears the most promising.

C.(M). lanchesteri can flourish and breed under pond conditions. It is eurytopic with respect to most environmental factors and seems to be well adapted to the soft waters found in most parts of Malaysia. It is not cannibalistic, at least under normal conditions, and appears to be vegetarian. Though it is of rather small size, it is larger than many other prawns which are of economic importance. Moreover it occurs in large numbers and can attain a larger size under specially favourable conditions. All of these features indicate its suitability for pond culture provided that adequate demand and adequate collecting and marketing facilities are available.

In ponds C.(M). lanchesteri competes with herbivorous food fish. It is not known how far this depresses fish production, but Dr Chen Foo-Yan of the Tropical Fish Culture Research Institute, Malacca, informs (personal communication) that there is some evidence that the presence of large numbers of prawns is associated with lower yields of algal feeding fish, while invertebrate feeders may benefit. It may well prove very difficult for a fish farmer to exclude C.(M). lanchesteri from his ponds. In ponds stocked with algae-feeding fish the presence of the prawn will adversely affect fish production. Exploitation of the prawn, if economically feasible, would turn an unavoidable loss into a definite gain.

In drawing attention to a species which appears to be potentially valuable, it is suggested that further research be undertaken not merely on its biology but also on relevant economic and sociological factors before it can conclusively be decided what use, if any, can be made of this riceland prawn.

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RELATION OF TEMPERATURE TO GROWTH AND SELF-PROPOGATION OF Pandalus borealis IN NEWFOUNDLAND

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Abstract

Pandalus borealis, the deep-water prawn or the pink shrimp, is abundant in waters deeper than 100 fm (200 m) near Newfoundland. Some of the P. borealis populations live throughout the year in temperatures close to 5°C. Individuals from such populations apparently become females in their fourth year and spawn annually in the next two or three years that they live. The proportion of females in all samples from these populations is high, and propagation would possibly be enough to maintain large numbers if they were fished. On the other hand, some populations live in temperatures close to 0°C. The proportion of females in these is consistently low and natural mortality may ensue before most males become females. These cold-water populations appear to be scarcely self-propagating and are not likely to withstand intensive fishing. The warm-water populations, however, appear suitable for commercial exploitation.

INFLUENCE DE LA TEMPERATURE SUR LA CROISSANCE ET LA REPRODUCTION DE Pandalus borealis EN TERRE-NEUVE

Résumé

Pandalus borealis, crevette d'eau profonde ou crevette rose, se rencontre en abondance près de Terre-Neuve à une profondeur supérieure à 200 mètres. Certaines populations de P. borealis vivent toute l'année dans des eaux où la température est proche de 5°C. Dans ces populations, il semble que les individus deviennent des femelles au cours de leur 4ème année d'existence et pondent au moins deux fois en deux ans. La proportion de femelles de tous les échantillons de ces populations est élevée, et il est possible que leur reproduction soit suffisante pour assurer le maintien d'un stock important de crevettes si elles faisaient l'objet d'une exploitation commerciale. Par contre, certaines populations vivent à une température proche de 0°C. La proportion de femelles est alors toujours faible et la mortalité naturelle peut intervenir avant que la plupart des mâles ne changent de sexe. Il semble que ces populations d'eau froide arrivent à peine à maintenir leurs effectifs et ne se prêteraient pas à une exploitation intensive. Les populations d'eau chaude cependant, se prêteraient à une exploitation commerciale.

RELACION DE LA TEMPERATURA CON EL CRECIMIENTO Y LA AUTOPROPAGACION DEL Pandalus borealis EN TERRANOVA

Extracto

El camarón de aguas profundas (Pandalus borealis) abunda en Terranova en aguas cuya profundidad es superior a las 100 brazas (200 m). Algunas poblaciones de P. borealis viven durante todo el año en aguas con temperaturas aproximadas a los 5°C. Ejemplares de dichas poblaciones se transforman, aparentemente, en hembras en su cuarto año y desovan anualmente en los dos o tres años futuros de su ciclo de vida. La proporción de hembras en todas las muestras de estas poblaciones es elevada, y la propagación sería posiblemente suficiente, si se pescaran, para mantener grandes cantidades de las mismas. Por otra parte, existen algunas poblaciones que viven en aguas con temperaturas cercanas a 0°C. La proporción de hembras en estas últimas poblaciones es considerablemente baja y la mortalidad natural suele suceder antes de que la mayoría de los machos se transformen en hembras. Estas poblaciones de agua fría no parecen autopropagarse mucho y no es probable que resistan a una pesca intensiva. Las de agua templada, sin embargo, aparecen convenientes para su explotación comercial.

1 INTRODUCTION

1.1 Survey of Newfoundland area for shrimp grounds in 1957 and 1958

During the summers of 1957 and 1958 a survey was made to determine the distribution of fishable quantities of Pandalus borealis (deep-water prawn or pink shrimp). Deep-water areas (100 to 200 fm, (200 to 365 m)) only were surveyed near Newfoundland (Squires, 1961).

1.1.1 Gulf of St. Lawrence and southwest of Newfoundland, warm-water channels The shrimp (P. borealis) was found in abundance, up to 400 lb (181.4 kg) per h, trawling in the deep-water channels (chiefly Mingan and Esquiman Channels) of the Gulf of St. Lawrence and southwest of Newfoundland as far east as Hermitage Bay. Catches were mostly composed of this one species of shrimp only. Because of penetration of Atlantic water into these level and soft bottom channels, temperatures remain moderately high (4 to 6°C) throughout the year.

1.1.2 South and east coasts of Newfoundland, cold-water bays Shrimps were also found but in less abundance (up to 130 lb (59 kg) per h, but generally much less) in Fortune, Placentia, Conception, Trinity and Bonavista Bays. Catches of shrimps were mostly composed of mixed species from these bays, the two abundant species being P. borealis and P. montagui. Bottom water temperatures in these bays were generally low. In some bays (Placentia and Conception Bays) the deep troughlike part of the bay is filled with cold Arctic water (close to 0°C) throughout the year. In the others deep bottom water of mixed Atlantic and Arctic origin have temperatures which are mostly below 1.5°C.

2 Pandalus borealis FROM DIFFERENT TEMPERATURES

2.1 Sizes of shrimps from temperatures of 4 to 6°C

Shrimps from the warm areas were larger than those from cold areas. Random samples of the catches from southwest Newfoundland gave "heads on" counts of 45 to 62 per lb (99 to 136 per kg) and from the Gulf of St. Lawrence 52 to 83 per lb (114 to 183 per kg). Averages and ranges of carapace lengths from these areas were, respectively, 25 mm (16 to 32 mm) and 23 mm (14 to 31 mm) (Squires, 1965). Samples of P. borealis from the relatively warm-water areas had an almost equal number of females as males. In samples from 16 hauls at temperatures of 3.7 to 6.2°C the proportion of females in samples varied from 26 to 58 percent (Fig. 1).

2.2 Shrimps from temperatures near 0°C

Most shrimps from low temperature areas were small in size. "Heads on" counts were 97 to 163 per lb (213 to 359 per kg) in Placentia Bay, over 200 per lb (440 per kg) in Conception Bay, 70 to 232 per lb (154 to 510 per kg) in Trinity Bay and 204 to 271 per lb (449 to 596 per kg) in Bonavista Bay (Squires, 1961). The average and range of carapace lengths in Placentia Bay, for example, was 15 mm and 10 to 28 mm (Squires, 1965).

The proportion of female P. borealis in samples from these areas was consistently low: some had no females while others had only 4 to 14 percent females (Fig.1).

3 PROBABLE AGE STRUCTURE OF POPULATIONS OF P. borealis IN NEWFOUNDLAND

When specimens of P. borealis from subsamples were separated in heaps according to size, about four groups of males and three of females were apparent. Length frequencies of specimens taken monthly during 1947 to 1957 also exhibited size groups, and these were estimated to represent ages of two to four years in males and transitionals and four to six years in females (Fig. 2). However, discontinuities occurred between

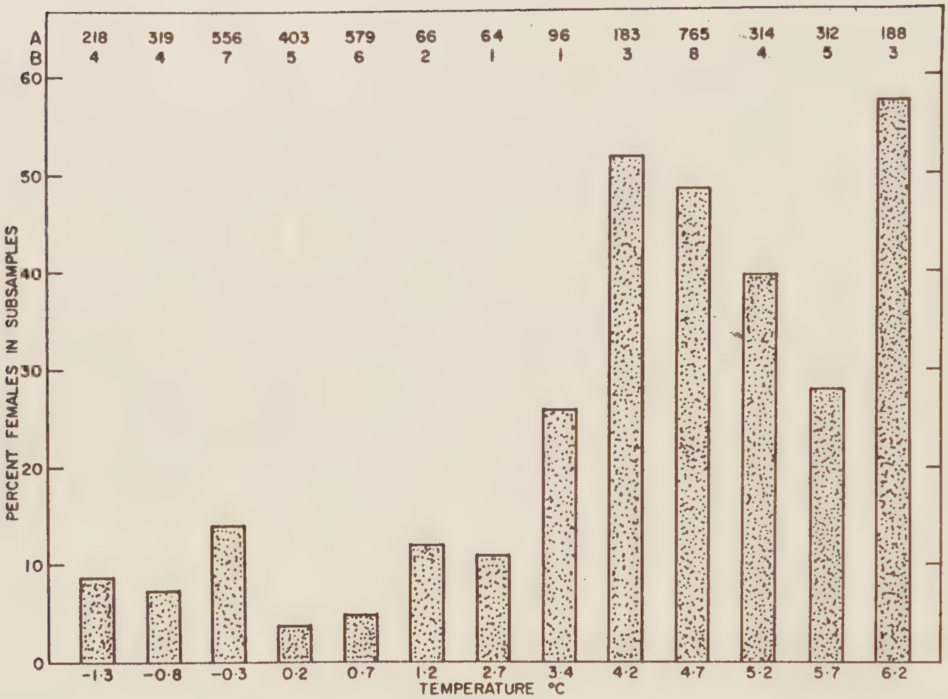

Fig. 1 Proportion of females present in samples from populations of Pandalus borealis living in different prevailing temperatures (unchanging throughout the year).

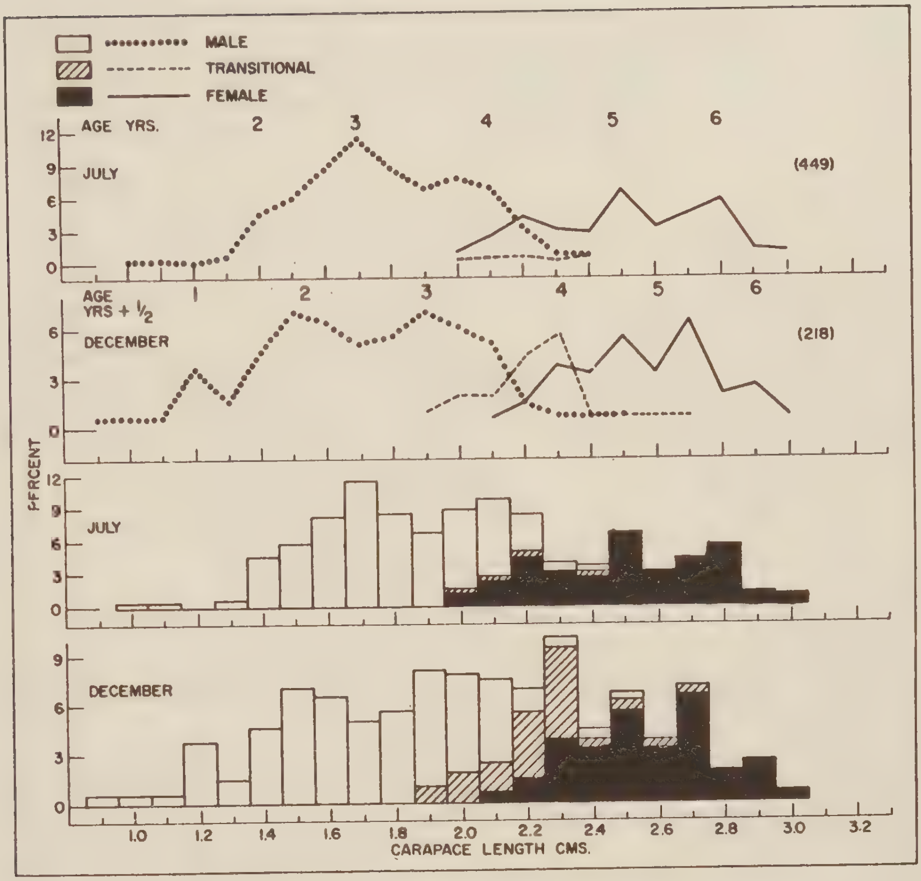

Fig. 2 Estimated ages of Pandalus borealis in grouped data from several areas in Newfoundland collected in July and December, 1947 to 1957.

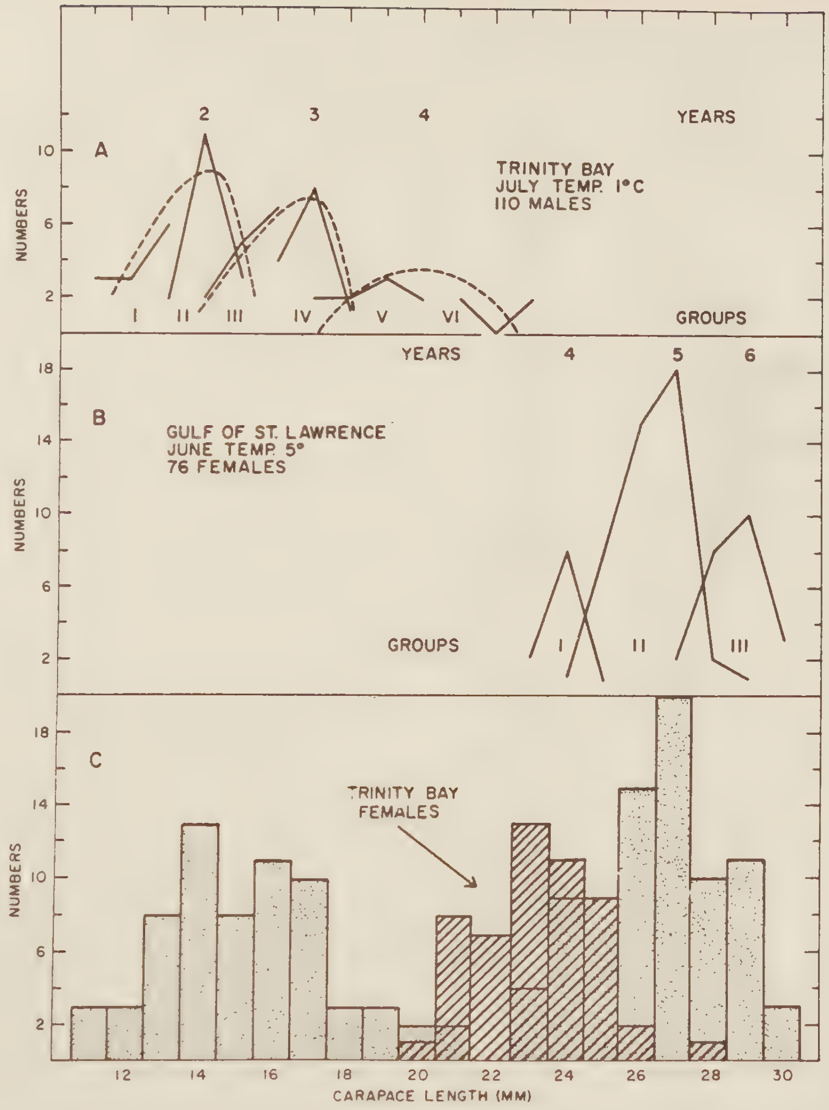

Fig. 3 Estimated ages of P. borealis in A. males from Trinity Bay (July) and B. females from Gulf of St. Lawrence (June). C. females from Trinity Bay are added to show size distribution of females from comparatively low temperatures in 1957.

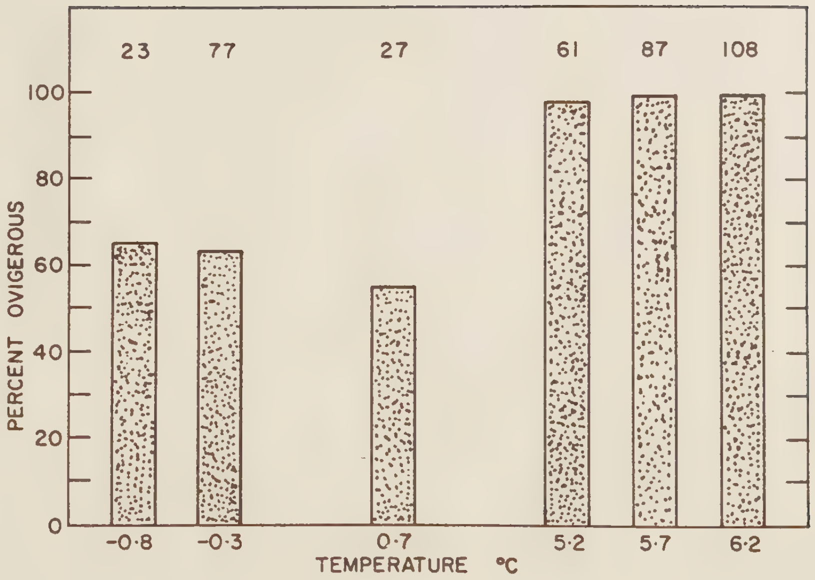

Fig. 4 Percent of ovigerous females annually in samples from P. borealis populations living in different prevailing temperatures (Unchanging throughout the year), 1957 and 1958.

male and female length frequencies from different areas. For example a discontinuity represented by at least one year's growth appeared to occur between males from Trinity Bay and females from the Gulf of St. Lawrence (Fig. 3). When lengths of females from Trinity Bay were filled in, a difference in growth rate became evident. Shrimp from the warm-water area had apparently grown faster than those from the cold-water area.

Since the females from the cold-water area were relatively much fewer in number than those from warm water and also smaller in size, it is presumed that in the cold-water area the growth limit is reached before most males became females. Males would appear older than their sizes suggest and therefore, what would seem a four-year age group would perhaps be a five- or six-year group. The few females occurring could be accounted for by-faster growing individuals in the population.

4 REPRODUCTION

4.1 Areas of high reproductive potential

In the warm-water areas where catch samples yielded as many females as males, almost all females would spawn annually (Fig. 4), in the two or three years of life as females. At such a rate of spawning these populations would most likely produce enough eggs and larvae to maintain their numbers. Also the configuration of the Gulf of St. Lawrence and the channels southwest of Newfoundland is such that, under prevailing winds, larvae would be most likely to settle near the bulk of the population producing them.

4.2 Areas of low reproductive potential

In cold-water areas, where P. borealis females occurred in much smaller numbers than males, less than 65 percent of them would spawn annually during the two or three years they would live (Fig. 4). With such a reduced rate of self-propagation, the populations of these shrimps would have difficulty in maintaining their numbers. They might owe their existence to larvae drifting from other populations. Presuming that larvae come to the surface of the sea after hatching in spring, they would be subjected to relatively low temperatures south and east of Newfoundland. They would, therefore, develop slowly while they were carried by prevailing currents south and westward. Some larvae from Conception and Trinity Bays might in this way eventually be deposited in Placentia Bay.

5 DISCUSSION AND CONCLUSIONS

5.1 Comparison of shrimp samples from different areas

Because the P. borealis grounds near Newfoundland have not yet been fished, it has been possible to compare populations from 0°C waters with those from 4 to 6°C. These temperatures on the shrimp grounds prevail throughout the year. The low-temperature areas have P. borealis populations which appear to be scarcely self-maintaining. Under exploitation such populations are not likely to be able to yield commercial quantities of shrimps. The warm-temperature areas, on the other hand, appear to have P. borealis populations which are self-maintaining at high numbers. Reproductive potential in these is apparently high because females in samples were equally as plentiful as males and 100 percent of them would spawn annually.

Conditions in these areas are typically stable. Seasonal or other migrations of adult shrimps are shown to be unlikely by many samples of similar composition obtained from these unfished populations at different times in the year.

5.2 Recommendation to the fishing industry

While the fishing industry could be advised to fish the warm-water populations of *P. borealis* and to locate processing plants near these grounds, they had best be advised not to depend upon fishing the shrimp grounds where water temperatures were low throughout the year. The shrimp grounds near Newfoundland, where temperatures are 4 to 6°C throughout the year, would undoubtedly support a continued fishing effort.

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FOOD AND FEEDING OF SOME AUSTRALIAN PENAEID SHRIMP

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Abstract

Food of the Australian commercial penaeid shrimps, *Penaeus esculentus*, *P. merguiensis*, *P. plebejus*, *Metapenaeus bennettae*, and *M. macleayi*, was found to consist of the remains of small animals and a large amount of unrecognizable material. It is suggested that the latter forms the main component of the diet, and that shrimps derive this by browsing on the micro-organisms (bacteria, algae, and micro-fauna) which grow on the surface of the substrata. Gross structure and function of the gut are described. Digestion and assimilation were found to be largely completed within six hours at 20°C, and this is attributed to the finely divided nature of the food. The need for detailed study of the productivity of the micro-organisms of the estuarine and inshore substrata is discussed.

NOURRITURE ET HABITUDES ALIMENTAIRES DE CERTAINS PENAEIDAE D'AUSTRALIE

Résumé

On s'est aperçu que la nourriture des Penaeidae d'Australie présentant un intérêt commercial (*Penaeus esculentus*, *P. merguiensis*, *P. plebejus*, *Metapenaeus bennettae*, et *M. macleayi*) consistait en des restes de petits animaux et une forte quantité de matériaux non identifiés. On suppose que ces derniers forment le principal élément du régime alimentaire et que les crevettes se les procurent en broutant les micro-organismes (bactéries, algues et micro-faune) qui poussent à la surface du substrat. La communication contient une description sommaire de la structure et des fonctions du tube digestif. L'expérience montre que la digestion et l'assimilation sont en grande partie terminées au bout de six heures à 20°C, phénomène que l'on attribue au fait que la nourriture est constituée de fines particules. L'auteur examine la nécessité d'entreprendre une étude détaillée de la productivité des micro-organismes rencontrés dans le substrat des estuaires et des zones côtières.

LOS ALIMENTOS Y LA ALIMENTACION DE ALGUNOS PENEIDOS AUSTRALIANOS

Extracto

Se ha comprobado que la alimentación de los camarones comerciales *Penaeus esculentus*, *P. merguiensis*, *P. plebejus*, *Metapenaeus bennettae*, y *M. macleayi* consiste en residuos de pequeños animales y en una gran cantidad de material irreconocible. Se supone que este último forma el componente principal de su alimentación, y que los camarones lo obtienen buscándolo cuidadosamente entre los microorganismos (bacterias, algas y microfauna) que crecen sobre la superficie de los substratos. Se describen la estructura general y la función del intestino. Se ha comprobado que la digestión y la asimilación se hacen en general en menos de seis horas a 20°C, atribuyéndose esto a la naturaleza muy dividida de los alimentos. Se discute la necesidad de realizar un estudio detallado de la productividad de los microorganismos de los substratos de los estuarios y de aguas cercanas a la costa.

1 INTRODUCTION

Until recently, the Natantia (shrimps) as a group have been neglected by crustacean physiologists, though the shallow-water Penaeidae comprise the bulk of the shrimp resources of the world. Most of the research has been carried out in temperate latitudes where the population of Natantia is small, or individuals themselves are small. Yet shallow-water Penaeidae are not difficult to maintain in tanks or ponds for experiments, and, apart from their great economic importance, are intrinsically interesting as the most primitive decapod family (Calman, 1909). Early investigations on the Paneaidae dealt with systematics and field biology, though much still remains to be done in these fields in many countries.

Study of food, feeding and assimilation are of fundamental importance in understanding the rate of growth, population concentrations, gonadial maturation and other metabolic activities. This paper is a consideration of the food of penaeids, their feeding, and some aspects of digestive-tract functions and assimilation.

2 MATERIALS AND METHODS

This study was carried out in Moreton Bay and adjacent waters in the vicinity of Brisbane, Australia. The following species were studied: *P. esculentus* (tiger prawn) *P. merguiensis* (banana prawn), *Penaeus plebejus* (king prawn), *Metapenaeus bennettae* (greasy-back or green-tail prawn) and *M. macleayi* (school prawn). Investigations showed that there were no important generic or specific differences in food preferences, feeding, or digestive tract function within this group, and most attention was therefore devoted to *M. bennettae*.

All observations were made on freshly caught animals under laboratory conditions. Some of these need to be confirmed by field observations as noted by Fuss (1964). Standard glass aquaria 30 cm x 30 cm x 60 cm were used to contain the shrimp, with substrata obtained from shrimp grounds in Moreton Bay. Temperature was 20 - 25°C, and the water salinity 35 parts per mille. Experiments on rate of digestion were made at 20°C.

Dissections were made on freshly killed shrimp, and material for sectioning was fixed directly from living animals. For micro-anatomy formal-saline at 5°C gave the most satisfactory fixation. Sections were stained either with Mayer's haemalum or Mallory's triple stain.

Food was labelled with finely divided silver - 110m (average particle size 5) and counted in a well-type crystal in an "EKCO" scintillation counter.

3 OBSERVATIONS AND RESULTS

3.1 Food and feeding

Detailed investigations have been made (Gopalakrishnan, 1952) on the "stomach" (anterior proventriculus) contents of the Indian prawn, *Penaeus indicus*, the North American white, brown, and pink shrimps (*P. setiferus*, *P. aztecus*, *P. duorarum*, respectively) by Williams (1955), and on *P. duorarum* by Eldred *et al.* (1961). In all cases there is close agreement. Indigestible animal remains (chitin fragments, annelid jaws and setae), algal fragments, and sand comprise recognisable dietary components. Williams (1955) notes that unrecognisable debris forms a major component, and suggests that "soft material" may form the bulk of the diet. In general, penaeid shrimps have been described as "omniverous scavengers" or "detritus feeders".

The Australian species examined conform to the above pattern. In the laboratory, portions of muscle and other body tissues are readily eaten. Shrimps do not appear to be predators, but small sized, disabled or dying animals are readily attacked by starving shrimp. Shrimps may be maintained in captivity for a considerable period on a diet of ground beef liver mixed with vitamin-enriched powdered cereal. In all cases where the food forms a relatively large mass the method of feeding appears to be similar. The food-mass is held by the external maxillipeds, and the mandibles are used to bite or tear portions off, the maxillipeds are then used to push tough food away as it is grasped by the mandibles.

It is unlikely, however, that under natural conditions in a densely populated shrimp-ground, the proportion of larger food-masses would be adequate for full nutrition of the population. It has been tacitly assumed that this deficiency is made good by "detritus", but Guilcher (1962) points out that estuarine muds usually contain less than 10 per cent organic material. Only a part of this material could be of immediate food value to animals. While it is possible that this could be adequate to maintain a dense population if directly eaten, it is suggested here that the shrimps only browse on the epi-flora and epi-fauna of the mud substrata.

Williams (1958), discussing substratum preferences, notes that post-larvae grow better on a mixed diet of algae and nauplii than on either alone, but that a pure animal diet is better than a pure plant diet. Estuarine muds support a rich growth of bacterial colonies and filamentous and blue-green algae. This flora is inhabited by an abundant micro-fauna of Protozoa, harpacticoid copepods, nematodes and the like (larger algae and animals may, of course, be abundant also). Unfortunately, as Ryther (1963) points out, very little is known of the rate of production of benthic flora, and what is known is restricted to the larger algae. Freshly collected estuarine muddy sand rapidly establishes itself in the laboratory into a superficial aerobic layer and a deeper, black, anaerobic layer. The superficial layer, if undisturbed, soon supports an abundant growth of bacterial colonies, and later algae and micro-fauna appear. A 10 cm _Metapenaeus bennettae_ can survive for over three months on about 300 cm^2 of such a substratum. The shrimp feeds by moving slowly over the surface, methodically searching the surface with the three pairs of chelipeds. Each chela, particularly the first pair (Fig. 1) is covered with numerous tufts of setae which appear to be gustatory in function. The tips of each chela meet precisely, so that quite small particles may be picked up and conveyed to the mouth. A row of heavy, tooth-like setae lining the inner edges of the chela enable larger masses to be gripped. Most of the food gathering appears to be done by the tips of the chelae. This browsing behaviour occupies a major proportion of the time when shrimp are active. Estimates were made of the relative volumes of the very fine material in the posterior proventriculus ("filter press") plus the proximal portions of the digestive gland tubules, and of the contents of the anterior proventriculus ("stomach") in actively feeding animals. In many cases the fine material was approximately equal in volume to the coarser unsorted material of the "stomach", and appears to confirm Williams' (1955) suggestion that "unrecognizable material" may comprise a major part of the diet. This material could consist of triturated detritus, but is more likely to be bacterial colonies, small algae and micro-fauna.

3.2 Structure and function of the gut

Young (1959) has published a description of the gut of _Penaeus setiferus_. The overall structure is shown in Fig. 2 and differs little in the shallow-water penaeids examined, except in details of the gastric mill (Dall, 1957). _Penaeus_ spp. differ from the two _Metapenaeus_ spp. examined, in that the posterior diverticulum of the mid-gut, is compact in the former, while it is a longitudinal, simple structure in the latter.

The oesophagus is short and leads vertically into the anterior chamber of the proventriculus ("stomach"), which serves as a distensible crop, and posteriorly, as a gastric mill. In the floor of the anterior chamber is a system of grooves which enable secretions from the digestive gland to be passed forward and mixed with the food.

The posterior proventriculus is partly embedded in the digestive gland and is divided into a dorsal channel which leads directly into the long simple mid-gut, and a ventral "filter-press" which permits only the finest particles to pass into the digestive gland.

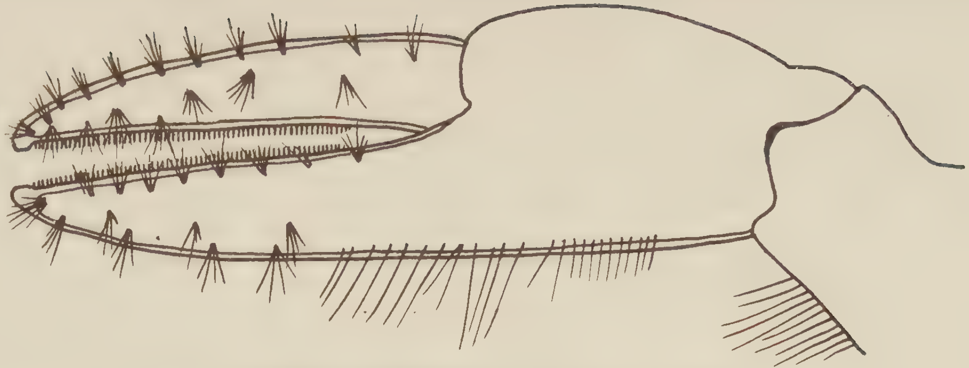
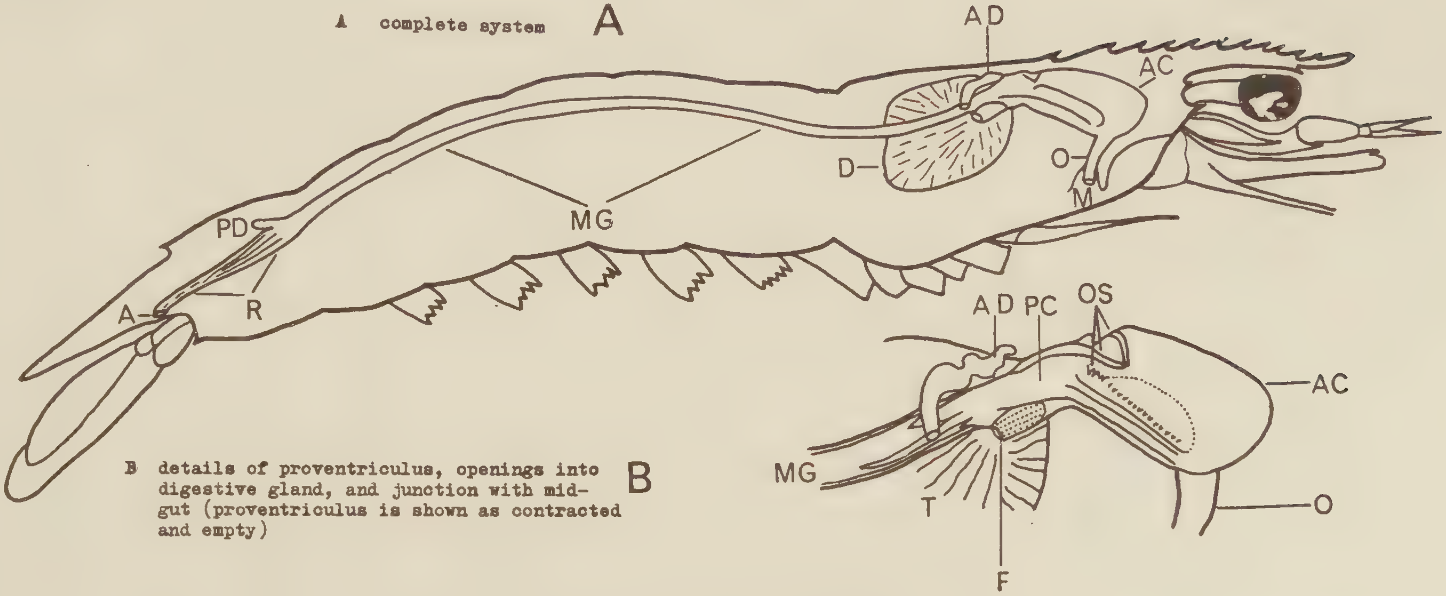


Fig. 1 First chela of Metapenaeus bennettae showing tufts of sensory (gustatory) setae, and inner rows of peg-like setae.



A complete system

B details of proventriculus, openings into digestive gland, and junction with mid-gut (proventriculus is shown as contracted and empty)

A	anus
AC	anterior chamber of proventriculus ("stomach")
AD	anterior diverticulum of mid-gut (this is a paired structure)
D	digestive gland
F	opening (paired) from "filter press" of posterior diverticulum into digestive gland
M	mouth
MG	mid-gut
O	oesophagus
OS	ossicles of gastric mill
PC	posterior chamber of proventriculus
PD	posterior diverticulum of mid-gut
R	rectum
T	tubules of digestive gland

Fig. 2 The digestive tract of a penaeid shrimp (slightly diagrammatic).

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Paired openings from the ventral "filter-press" lead into the digestive gland. This organ is compact in shape and forms 3 to 4 percent of the total weight of the shrimp.The glands constitute a significantly larger proportion of the body weight in females than in males. The openings from the proventriculus lead directly into the simple tubules which comprise the gland. The tubule walls are a single layer of epithelium in which two cell types may be distinguished: a secretory type, and a "storage" type which contains polysaccharides (Dall, 1965).

Fujii et al. (1963) report powerful proteinases in the digestive gland of Penaeus orientalis. It is likely that all shallow-water penaeids are similar in this respect, and the very rapid post-mortem autolysis of digestive glands, characteristic of shrimps, is probably due to these enzymes. An amylase, equivalent to approximately 40 units per gram (wet weight) was found to be present (activity of human salivary amylase usually 100 - 150 units per ml). Digestive gland secretions also emulsify fats and it is probable that lipases are present, though these were not specifically looked for. As noted long ago by Yonge (1924) omnivorous Decapoda appear to possess a "full complement" of enzymes, and penaeid shrimps appear to be no exception.

By the time the food particles have reached the digestive gland, digestion is well under way, and is completed in the proximal half of the digestive gland tubules. No food particles can ordinarily be detected in the distal portions of the tubules, and presumably digestion is complete by the time the food has reached this level. It is not clear how the digestive gland is filled, nor if indigestible residue is ejected from the gland. Dall (1967) suggests that filling is accomplished by a combination of water ingestion and action of the proventriculus muscles. Any emptying may occur in much the same way. The fate of large indigestible particles is much clearer. These pass through the dorsal part of the posterior proventriculus into the mid-gut which secretes a peritrophic membrane. When the mid-gut is filled with particles the peritrophic membrane is grasped by longitudinal "pads" in the rectum and expelled. Thus fresh faecal pellets of penaeids consist of lengths of peritrophic membrane approximately equal to the mid-gut in length.

The anterior and posterior diverticula of the mid-gut appear to be concerned with osmotic and ionic regulation (Dall, 1967), and have no role in digestion.

3.3 Rate of digestion

The anterior chamber of the proventriculus is filled to capacity within two minutes when a starved shrimp is provided with abundant soft food. Ingestion then ceases until some food has passed through the gastric mill. Shrimp from "rich" feeding grounds have the proventriculus at least partly filled while they are active. Pre-moult animals, in common with other Decapoda, do not feed (Dall, 1965). During "browsing" the rates of ingestion and digestion are probably equal, so that the relatively small "stomach" is not a major disadvantage. Dall (1964) has shown that Metapenaeus bennettae (as M. mastersii) has little in the way of food reserves, and that regular feeding is essential for survival. This may not apply to species such as Penaeus merguiensis and Metapenaeus macleayi which migrate to a certain extent (Racek, 1959).

Defecation may begin in a starved animal an hour after feeding, reaches a peak in four to six hours, and if feeding is confined to the beginning of the experiment, virtually ceases by eight hours. Food labelled with silver-110m shows, however, that some residue may remain in the gut up to 20 h. The digestive gland begins filling almost immediately food is taken into the proventriculus. Dall (1965) found that labelled glucose was absorbed very rapidly, and that carbon-14 carbon dioxide appeared one hour after introduction into the proventriculus. It seems likely then, that assimilation can be very rapid, and this would be particularly so if the bulk of the food consists of very small particles (micro-organisms or otherwise). This is consistent with indications that penaeids may have a high metabolic rate when active, coupled with low food reserves (Dall 1965). Their dependence on suitable substrata would be partly offset by their being omnivorous with efficient and rapid food assimilation.

4 DISCUSSION

From the foregoing, it is obvious that more attention should be paid to the nature of penaeid food and its production. Williams (1958) has shown that there may be a species preference for a particular type of substratum, and suggested food as one cause. If commercial penaeid species are mostly feeders on micro-flora and micro-fauna, then a full study of these organisms and their production is warranted. This would ultimately enable the fisheries biologist to make better estimates of the size of the stock that can be supported in any given area. Factors which cause sudden population fluctuations or migrations could well be bound up with successions of micro-organisms and the smaller algae, for example. Some knowledge of utilization is also desirable in order to ascertain which organisms have the highest nutritive value. The implications of this in pond culture are obvious. Also, a more detailed knowledge of the reasons for shrimp substratum preference might enable exploratory shrimp fishing to be much more effective than it is at present.

Further investigation of digestive gland fuctions is also desirable, apart from actual food digestion. The digestive gland in Decapoda is generally regarded as a storage organ as well as a digestive gland, but histologically there is no evidence of a large volume of storage cells in Penaeidae. Yet the relatively larger size of the female digestive gland is presumably in some way associated with the greater amount of synthesis required for ovarian development and maturation. This is a completely unknown area of shrimp physiology.

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REPRODUCTION OF THE SAND SHRIMP, Crangon crangon (L.)

by

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Abstract

An investigation was made on the reproductive cycles of the sand shrimp, Crangon crangon (L.). The shrimps were reared under controlled laboratory conditions from larval to sexually mature stages. Crangon always oviposited after moulting, provided the ovarium had reached the third abdominal somite. Examining freshly caught shrimps against a source of light, one is able to determine this final stage. By use of this technique, estimates on reproductive cycles can be obtained.

REPRODUCTION DE LA CREVETTE DE SABLE Crangon crangon (L.)

Résumé

L'auteur étudie le cycle reproductif de la crevette de sable Crangon crangon (L.). Les crevettes ont été élevées en laboratoire, depuis le stade larvaire jusque'à la maturité sexuelle. Crangon effectue toujours sa ponte après la mue, à condition que l'ovaire ait atteint le troisième somite abdominal. En examinant à contre-jour les crevettes qui viennent d'être prises, on peut déterminer ce stade final. L'utilisation de cette technique permet d'obtenir des estimations relatives aux cycles reproductifs.

LA REPRODUCCION DEL CAMARON *Crangon crangon* (L.)

Extracto

Se realizó una investigación sobre los ciclos reproductivos del camarón de arena *Crangon crangon* (L.). Los camarones se criaron en el laboratorio en condiciones controladas desde la fase larval hasta la madurez sexual. *Crangon* deposita siempre los huevos después de la muda, a condición de que el ovario haya alcanzado el tercer segmento abdominal. Si se examinan camarones recién capturados frente a la luz se puede determinar esta fase final. Empleando esta técnica se pueden obtener estimaciones acerca de los ciclos reproductivos.

1 INTRODUCTION

The sand shrimp Crangon crangon (L.) sustains an important fishery in Dutch and German waters. The catches are obtained mostly in the tidal zone of the North Sea. In German coastal waters Crangon probably attains sexual maturity at an age of less than one year and a length of about 50 mm. Meyer-Waarden (1935), Tiews (1954) and Kühl (personal communication) agree that Crangon spawns more than once a year. Reproduction shows a distinct seasonal rhythm resulting in a maximum of shrimp larvae in summer and a minimum in winter (Kühl and Mann, 1963; Plett, 1965).

2 REPRODUCTIVE CYCLES

At present there is little information on the number and quantity of ovipositions per female per annum. Berried females are caught in a varying percentage throughout the year. In German coastal waters incubation varies from about 3 mo in the winter to 3 weeks in the summer, depending on the temperature. Rates of reproduction are often under-estimated because it is overlooked that shrimps may moult and spawn again shortly after hatching. To help calculate the number of annual ovipositions per female, the following observation may be of use. At an advanced stage of incubation Crangon eggs show dark spots - the compound eyes of the embryos. At this stage it is possible to determine whether or not the females will spawn again after the next moult (see below).

3 EXPERIMENTS

The earlier-mentioned observations of Meyer-Waarden, Tiews and Kühl regarding reproductive cycles of females, was followed by rearing Crangon under controlled conditions from larval to sexually mature stages by Meixner (1966a).

In the present study the size of the reproductive glands was determined, at weekly intervals, holding the shrimps to an opalescent glass-pane lighted from below. At an age of 8 to 9 mo and a length of less than 50 mm a remarkable enlarging of the female reproductive glands was observed. Females oviposited first at the age of about 10 mo (Fig. 1). Some days after oviposition, renewed growth of the female reproductive gland was noticed. We found that at temperatures simulating those in the field during the period of breeding, optimum rations of food stimulated repeated egg-laying (Table I).

TABLE I

Moults and ovipositions of 5 female Crangon crangon under laboratory conditions. Experimental period: April to August 1965. Range of length: 55 to 65 mm. Temperature: 14°C (from 15 July 17° to 18°C). Salinity: 30 $^{0}/_{00}$. Food: Artemia salina (juvenile and adult)

Crangon No.	April	May	June	July	August	Total
I	+	+	+	+	+	5
II	+	-	+	-	-	2
III	+	+	+	-	+	4
IV	+	+	+	+	-	4
V	-	+	+	+	-	3

+ = moult and oviposition - = moult without oviposition

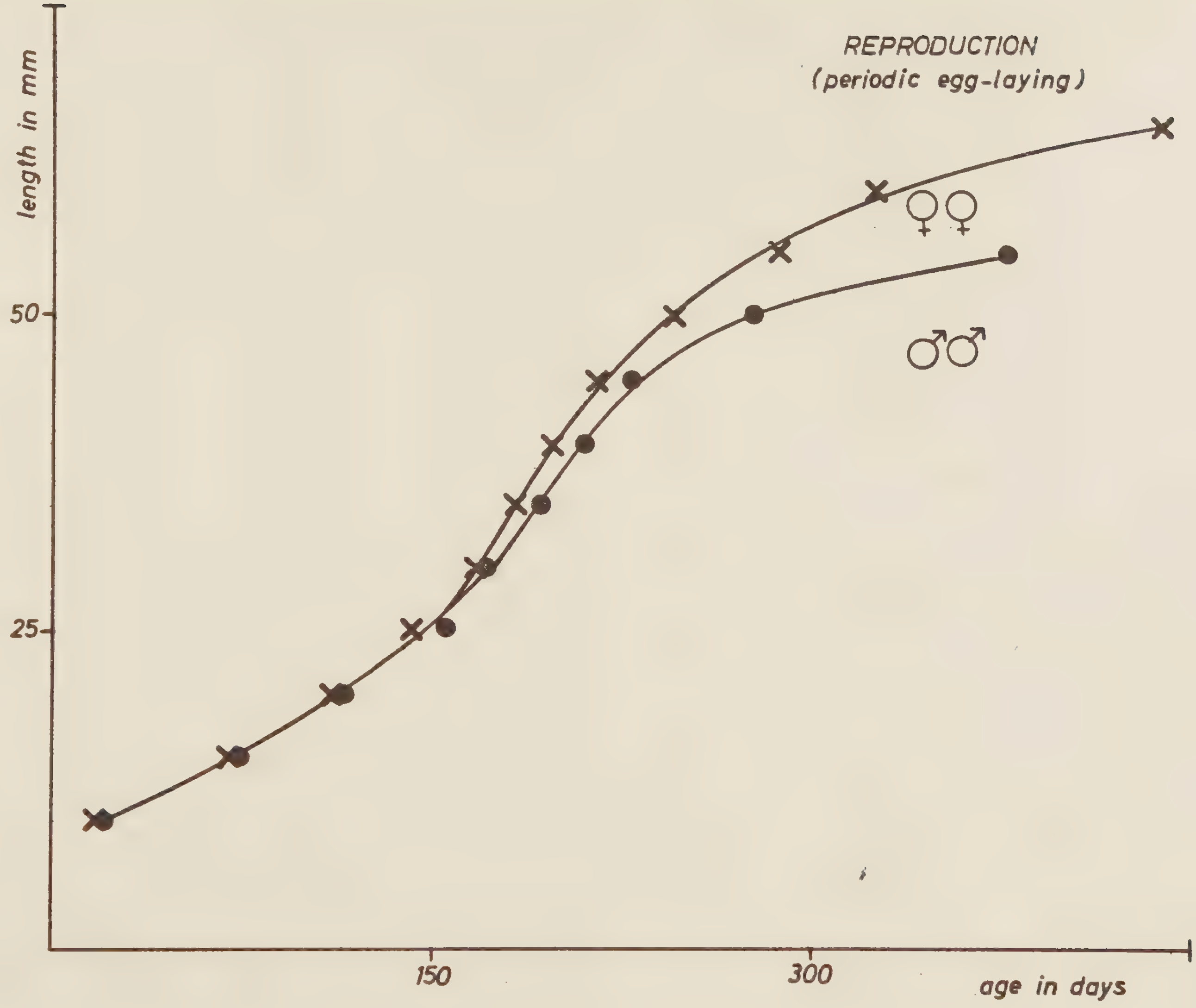

Fig. 1 Growth after metamorphosis and reproduction of 5 female and 20 male *Crangon crangon* (L.) under laboratory conditions. Temperature: 14°C. Salinity: 30 ‰. Food: larval and postlarval *Artemia salina*.

At temperatures of 14° to 18°C and at daily rations of food (juvenile and adult Artemia salina) of about 4 mg (dry weight) moulting and oviposition took place at 3 to 4 weekly intervals. Suboptimum rations of food slowed down ovarian growth, and the subsequent moult was not followed by oviposition (Table II). Increased rations of food again stimulated ovarian growth.

TABLE II

Influence of food uptake (mg dry weight) on oviposition of 4 Crangon crangon. Before the experiment all females had successfully spawned. Temperature: 18°C. Salinity: 30 ‰. Food: juvenile and adult Artemia salina

	♀ I	♀ II	♀ III	♀ IV
Experimental period (weeks)	3	3	3	3
Ration of food (mg)	96.7	82.8	40.2	53.4
Spawning after next moult	+	+	–	–

+ = moult and oviposition – = moult without oviposition

In all our experiments Crangon oviposited when the continuously enlarging ovaries reached the third abdominal somite. This stage was determined by viewing the individuals against a transmitted light. By this means it was possible to forecast any further oviposition.

4 CONCLUSIONS

It appears that it would be possible to obtain a reliable estimate of the number of ovipositions per female per annum on a basis of observations on the relative abundance of ovigerous shrimps (eye spot stage) and those showing, on examination, ovaries, which fill the body up to the third abdominal somite (terga). Investigations on reproductive cycles should be made at intervals determined by the moulting rhythm of sexually mature females. Some information on moulting rhythm was published by Tiews (1954) and Meixner (1966b), but further studies are needed to corroborate their observations.

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SIZE DISTRIBUTION AND MOVEMENT OF THE COMMERCIAL PRAWNS OF THE SOUTHWEST COAST OF INDIA

by

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Abstract

A detailed study of the distribution pattern of size and abundance of the commercial penaeid prawns of the southwest coast of India, *Metapenaeus dobsoni*, *M. affinis*, *M. monoceros*, *Penaeus indicus* and *Parapenaeopsis stylifera*, has been carried out based on the catches of the exploratory vessels belonging to the Government of India Offshore Fishing Station and the Indo-Norwegian Project, Cochin. The movements of these prawns in different depth zones of the fishing grounds, as seen from the analyses of data, are size-oriented. With the exception of *M. dobsoni*, all the species studied were seen to enter the fishing grounds from deeper zones by September, which is the beginning of the fishing season. They move out of the fishing grounds into the deeper zones from February to March onwards. *M. dobsoni*, however, seems to exhibit this movement in the opposite direction. The role of monsoon and upwelling in causing these movements, is discussed.

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REPARTITION PAR TAILLE ET DEPLACEMENTS DES CREVETTES D'INTERET COMMERCIAL DE LA COTE SUD-OUEST DE L'INDE

Résumé

Sur la base des prises effectuées par les bateaux de pêche d'exploration appartenant au Offshore Fishing Station (Gouvernement de l'Inde) et au Projet Indo-Norvégien de Cochin, on a entrepris une étude détaillée de la répartition par taille et par degré d'abondance des crevettes penéides pêchées commercialement sur la côte sud-ouest de l'Inde: Metapenaeus dobsoni, M. affinis, M. monoceros, Penaeus indicus et Parapenaeopsis stylifera. L'analyse des données montre que les déplacements de ces crevettes dans les différentes zones de profondeur des aires de pêche sont fonction de leur taille. On s'est aperçu qu'à l'exception de M. dobsoni toutes les espèces étudiées quittaient les eaux profondes pour pénétrer dans les terrains de pêche en septembre, c'est-à-dire au début de la saison de pêche. Elles regagnent ensuite les zones profondes à partir de février-mars. M. dobsoni toutefois semble effectuer le mouvement inverse. Les auteurs de la communication examinent le rôle de la mousson et des remontées d'eau dans ces déplacements.

DISTRIBUCION POR TALLAS Y MOVIMIENTO DE LOS LANGOSTINOS COMERCIALES DE LA COSTA SUDOCCIDENTAL DE LA INDIA

Extracto

Basándose en las capturas de los barcos de exploración pertenecientes a la estación de pesca de altura del Gobierno de la India y al Proyecto Indo-Noruego de Cochin, se ha realizado un detallado estudio del tipo de distribución por tallas y de la abundancia de los peneidos comerciales de la costa sudoccidental de la India, Metapenaeus dobsoni, M. affinis, M. monoceros, Penaeus indicus y Parapenaeopsis stylifera. Los movimientos de estos langostinos en diferentes zonas profundas de los caladeros, como se puede observar en los análisis de los datos, tienen relación con el tamaño. Con la excepción de M. dobsoni, pudo verse, hacia el mes de septiembre, que es cuando comienza la temporada de la pesca, que todas las especies estudiadas entraban en los caladeros procedentes de zonas más profundas. A partir de febrero-marzo salen de los caladeros hacia las zonas más profundas. Sin embargo, M. dobsoni parece realizar este movimiento en dirección opuesta. Como causa de estos movimientos se examina la función desempeñada por los monzones y las aguas de afloramiento.

1 INTRODUCTION

Prawn populations inhabiting the coastal waters around Cochin, on the southwest coast of India, support an intensive and valuable fishery. Detailed biological investigations on these commercial prawns have been initiated in the Central Marine Fisheries Research Institute ever since the fishery commenced on a large scale in 1956-57; and some of the results on the species and size compositions, distribution and their fluctuation from year to year have been reported (George et al., in press) The present contribution is the result of comprehensive studies conducted on abundance and size distribution of the different species during the period September 1961 to August 1964.

An important problem confronted by researchers is to determine whether primary prawn stocks are homogeneous over their ranges or whether they constitute discrete subpopulations overlapping in space, time, or both. The question is prompted mostly by the unique life history of the common penaeid prawns which support the fishery. In general, the eggs are spawned in the offshore habitat of the parent prawn. The hatched larvae, becoming a component of the zooplankton, are soon transported shoreward and into estuaries and backwaters. Here the prawn, now a postlarva, settles to the bottom and undergoes rapid growth during the ensuing few months. As maturation approaches it leaves these 'nursery' grounds to return to the parental offshore habitat, where the life cycle is completed. This being the set pattern of life cycle, the fact that most of the species spawn throughout the year with two or three peak spawning periods (George, 1962a; Rao, MS*) brings us to the possibility of regular ingress and egress of juveniles and adults of the different species in the fishing grounds. With the expansion of frozen shrimp exports from the country the demand for large sized prawns has increased considerably. Consequently, the need for locating grounds where bigger sizes of prawns are available and determining the time of their occurrence has become a necessity. In this connection an attempt is made to study the size oriented movement of the prawns in the fishing grounds off Cochin.

The total prawn catches of the trawlers operated from Cochin by the Indo-Norwegian Project and the Offshore Fishing Station of the Government of India are taken into account in computing the abundance factor. The area of operation of the boats and the depth zones are shown in Fig. 1. The size composition of the prawns is determined by regular analyses of samples of catches from all the trawlers. The measurements of prawns are given as total lengths in millimetres, from tip of the rostrum to the tip of the telson.

Throughout this paper the unit of abundance, as expressed by the catch in numbers per trawling hour, is denoted by $\underline{u}$, mean size by $\underline{m}$ (in mm) and size range by $\underline{r}$ (in mm). These parameters are analyzed for five depth zones as under:

Depth zone I . . . . 0 to 5 fm (0 to 9.1 m)

Depth zone II . . . 5 to 10 fm (9.1 to 18.3 m)

Depth zone III . . . 10 to 15 fm (18.3 to 27.4 m)

Depth zone IV . . . 15 to 20 fm (27.4 to 36.6 m)

Depth zone V . . . . 20 to 25 fm (36.6 to 45.7 m)

2 THE FISHERY

The fishery usually commences by September-October and extends till June-July, the fishing activities being almost suspended during the monsoon months. Generally, at the commencement of the season fishing operations are carried out in deeper areas, mostly restricted to the 15 to 25 fm (27.5 to 36.6 m) region, during which time the catches are relatively poor. But as the season advances the fishing activities are confined to lesser depths, mostly depending on the catches.

* This reference is now in press. (Ed.).

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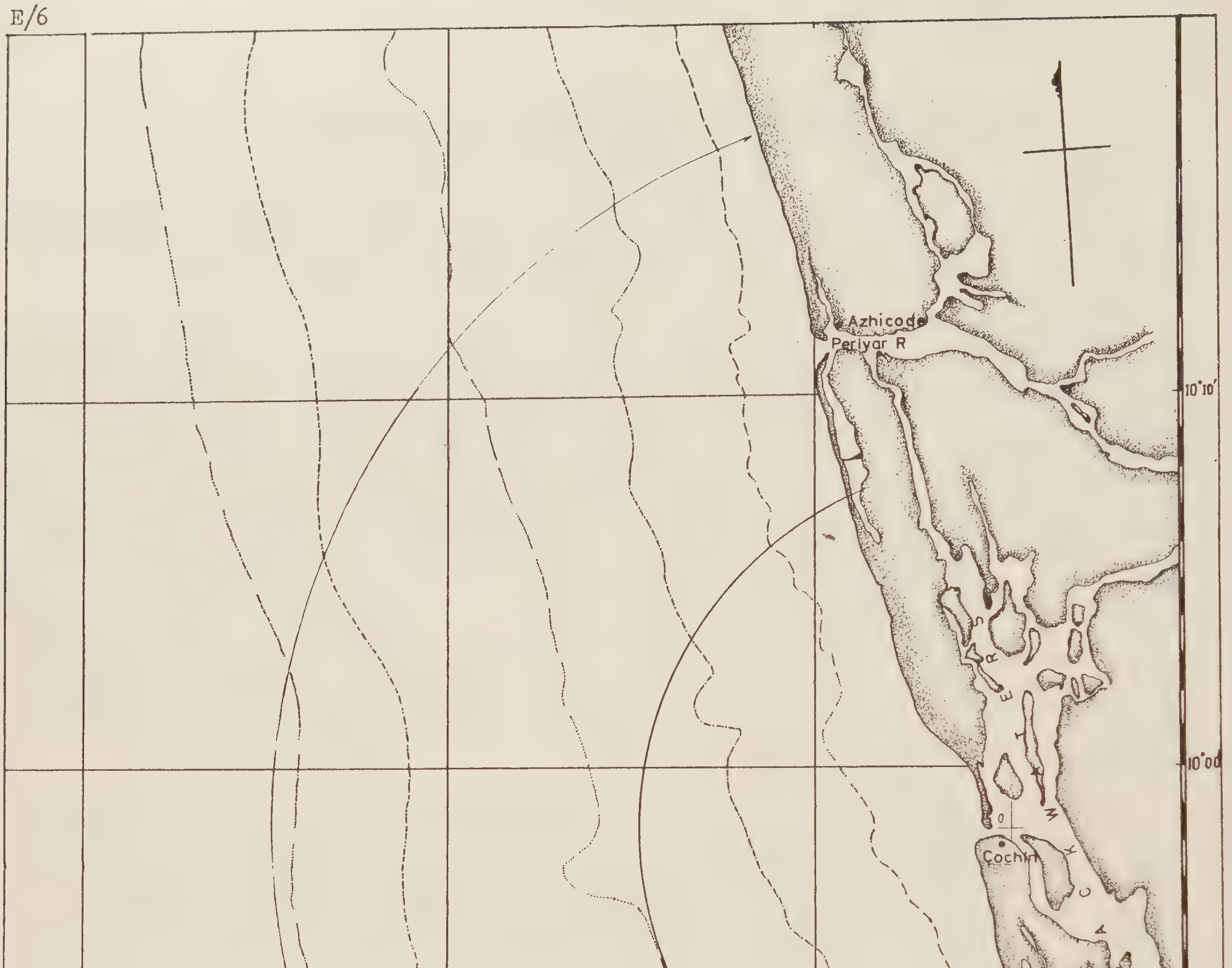

Fig. 1 Area of fishery and depth zones .

Vessels taking part in the shrimping activities of the area comprise mostly shallow draught pablo boats, powered by 10 to 30 bhp engines and owned by private agencies. A few bigger types of shrimp trawlers are also operated which usually concentrate their operations in deeper regions. The conventional two or four seam shrimp trawls are operated by these boats, making daily trips.

Five species of prawns of the family Penaeidae support the fishery. They are:

Metapenaeus dobsoni (Miers) ('Poovalan Chemmeen')
Metapenaeus affinis (H. Milne Edwards) ('Kazhanthan Chemmeen')
Metapenaeus monoceros (Fabricius) ('Choodan Chemmeen')
Penaeus indicus H. Milne Edwards ('Naran Chemmeen')
and Parapenaeopsis stylifera (H. Milne Edwards) ('Karikadi Chemmeen')

The first four species have the typical life cycle referred to earlier, but P. stylifera appears to spend the entire life cycle in the marine environment, there being no evidence of its postlarvae entering estuaries. Hence, some difference in the pattern of behaviour and movements in and out of the fishing grounds can, naturally, be expected in the case of this species.

3 ABUNDANCE AND SIZE DISTRIBUTION IN DEPTH ZONES

3.1 Metapenaeus dobsoni

Considerable information on the species from this region is available. The juveniles of the species contribute to a commercial fishery in the backwaters, while the adults form the bulk of the marine catch. According to Menon (1955), three year classes are represented in the fishery. However, George et al. (in press) record only two year classes in the offshore prawn fishery of Cochin. The species breeds throughout the year in these waters, with two definite peak spawning periods; one in June through August and the other in November-December. Rao (MS) records an additional peak spawning period in April. According to George et al. (in press) this is the most important species in the offshore catches as indicated by its percentage in the catches. The normal pattern of size distribution of the species shows the bigger first-year classes dominating early in the season, and later replaced by the smaller late 0-year classes, resulting in a gradual reduction in size of the species composition as the season advances. They have recorded a comparatively higher concentration of the species in the 7 to 8 fm (12.8 to 14.6 m) contour.

3.1.1 Abundance Depthwise distribution of u of the species is shown in Fig. 2. In 1961-62 there was fishing in zone I only during September and October, when u varied from 61 to 66. In zone II there was fishing from October to June. During this period, u varied from 13 to 10918, the highest being noted in March and the lowest in October. In zone III the highest u was also noticed in March, the numerical value being 5630. In zone IV, fishing was done only in February when u was very low and stood at 27 (Fig. 2).

In 1962-63 when there was fishing in zone II from November to June, u varied from 900 to 6031, the maximum occurring in February and the minimum in April. In zone III the operation was mainly in the months January to June and the maximum u was recorded in June.

In 1963-64 in zone II, u ranged from the minimum of 27 in October to the maximum of 4670 in December. During May and June there was no operation in this zone. In zone III, there was operation only in January, May and June with the maximum u of 1717 in June. In zone V there was fishing in May when u was 685.

3.1.2 Size The mean size m and the size range r at different depth zones are shown in Fig. 2. It would be seen that m varies considerably from month to month even in the same depth zone.

E/6

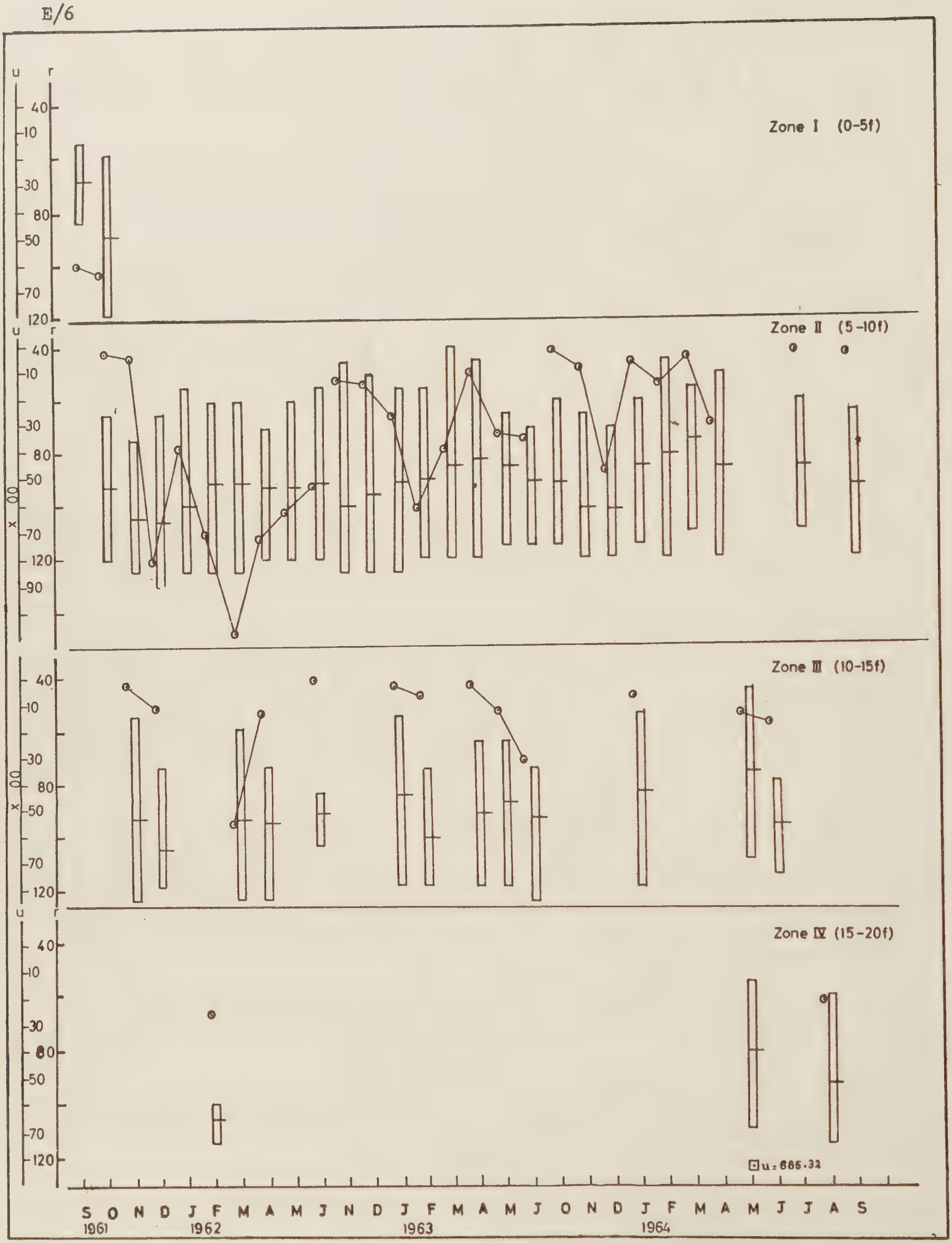

Fig. 2 Abundance and size of M. dobsoni during 1961-62 to 1963-64. Vertical column represents size range (r) and horizontal line on it the mean size in mm. Abundance (u) in number per trawling hour.

In 1961-62 *m* in zone II during October was 93.0. The highest mean size of 106.2 was reached in December and then declined. In zone III also the highest *m*, 106.7, was in December and the lowest, 92.4, in June. In zone IV there were fishing operations only in February when *m* was 106.8. The size ranges varied from 56-85 to 66-130 in different months.

In 1962-63 in zone II, *m* ranged between 82.5 and 99.7, which was comparatively lower than that of the previous year. The minimum was recorded in April and the maximum in November. In zone III the maximum *m* of 101.5 was recorded in February and the minimum in May. *r* varied from 41-120 to 76-125.

In 1963-64 in the lower depth zone, *m* varied from 75.5 to 101.6, the former in the month of March and the latter in December. In zone III it varied between 76.9 and 96.9 in the three months in which there was operation. *r* in this year ranged from 46-120 to 81-115.

3.1.3 Movements In a static population which is subjected to exploitation, decreasing abundance will be noticed due to both fishing and natural mortality as the season progresses, and at the same time increasing mean size will be encountered due to growth. But, the fluctuations in mean size and abundance, in the observations recorded above, indicate that the exploited population is dynamic and variable.

Increase in both *u* and *m* over any period in a particular zone could be attributed to incursions of large sized prawns into the zone, while a decrease in both these parameters would indicate the egression of these prawns from that area. Fresh recruitment of young prawns into the zone will be manifested in the increase of *u* and decrease of *m* and the reverse would be the result of either the movement of the small sized prawns out of the area, or, the effect of fishing and natural mortality, and the effect of natural growth processes.

In the case of *M. dobsoni* it may be seen from Fig. 2 that in 1961-62 in both zone II and III, *u* as well as *m* increased from October to December, indicating that larger prawns of the species were entering this area. In January, both *u* and *m* registered a fall in zone II, which might mean that larger size prawns were moving out of this zone. But from January to March, *u* increased while *m* decreased showing the incursion of small sized prawns into the area. In April, *u* dropped while *m* increased slightly in both these zones. This might have partly been due to excursion of some small prawns from the area and partly due to operation of mortality on the population. From April to June there was a decline in both *u* as well as *m* thereby indicating movement of bigger sized prawns out of the areas. Approximately similar trends were noticed in the 1963-64 season also. But in 1962-63, there was slight difference in the pattern of movement of the species. In this year from November to February there was continuous increase of *u* with corresponding decrease in *m* indicating incursion of small sized prawns into zone II. In zone III from January to February *u* doubled together with increase in *m* showing thereby movement of large prawns into the area. From February to April in both zones *u* as well as *m* declined which meant there was movement of big prawns out of the zones. From April to June *u* increased along with *m* which indicated an incursion of big prawns into the area.

It is therefore seen that from October to December the offshore migration of bigger sized prawns of the first year class of this species takes place. The fact that big sized prawns occurred in zone I during September-October of 1961-62 shows that these prawns were present very close to the shore towards the beginning of the season just after the monsoon. That this species may be remaining very near to the shore during the monsoon months has been expressed by George *et al.* (in press) based on the hypothesis of Banse (1959) that during upwelling periods fishes and prawns remain either pressed against the shore or migrate to deeper waters. The presence of this species in large concentrations very near the shore in mud-bank areas in the monsoon period supports this view. After monsoon the offshore movement seen in zone II in October continues to zone III till December-January. The incursions of prawns of smaller size belonging to the late O-year group into zone II commences in February. These late O-year class prawns which are recruited from the backwaters may probably belong to the brood of the peak spawning period June-July. During February-March, offshore migration of these small sizes takes place. From April-May not much offshore movement could be noticed.

TABLE I

Total number of individual *Metapenaeus dobsoni* caught, in thousands (C), and catch per trawling hour (C/E)

Size in mm	1961–62		1962–63		1963–64	
	C	C/E	C	C/E	C	C/E
41 – 45	–	–	11	3	–	–
46 – 50	–	–	23	7	3	2
51 – 55	–	–	35	11	13	8
56 – 60	9	2	48	14	25	14
61 – 65	63	13	105	31	57	33
66 – 70	117	23	385	116	132	77
71 – 75	730	148	847	254	239	139
76 – 80	1769	358	1124	338	284	165
81 – 85	3299	667	1386	416	263	152
86 – 90	5359	1084	1300	391	260	151
91 – 95	5429	1098	1428	429	251	146
96 – 100	6178	1250	1402	421	308	179
101 – 105	5188	1049	963	289	278	162
106 – 110	2051	415	377	113	108	63
111 – 115	2673	541	349	105	85	49
116 – 120	1352	274	183	55	46	27
121 – 125	238	48	14	4	–	–
126 – 130	11	2	–	–	–	–

In 1961-62, m in zone II was 105-106 in November-December and it declined to 92.1 in February and thereafter registered slight increase. In the other years also, more or less the same trend was noticed, indicating a general size-oriented migration which starts in November-December and ceases by March-April. The fact that m was higher in zone III than in zone II in all the months except November, 1961, and January, 1963, further strengthens this view.

3.1.4 Mortality From March to June 1961-62 in zone II it may be seen that u declined when m increased. If we assume that migratory movement has stopped by about that time, then the fall in u might have been due to mortality and increase in size due to growth. Then the total instantaneous mortality could be estimated by the formula

$$\log_e \frac{N_t}{N_t+1} = F + M \text{ , where}$$

N_t denotes the number of prawns of age t in any month and N_t+1 denotes the number of prawns of age t+1 in the next month. Since the absolute number of prawns is not known, the relative abundance may be used in making this calculation.

Taking the relative abundance of M. dobsoni between March and April 1962, the monthly instantaneous mortality would be

$$\log_e \frac{10918}{7340} = 0.40$$

The monthly instantaneous mortality rate between the months of April and May 1962 is given by

$$\log_e \frac{7340}{6242} = 0.17$$

and that between May and June 1962 by

$$\log_e \frac{6242}{5292} = 0.17$$

The above calculations show that probably some migration was still taking place in March in zone II, and only from April did the outward migration cease. The estimate of monthly instantaneous mortality rate may be taken as 0.17 corresponding to an annual instantaneous mortality rate of 0.17 x 12 = 2.04.

That this interpretation is correct can be verified by considering the entire fishing area, pooling together all zones, so as to do away with the effect of migration. Table I gives the catch (in numbers) and catch per unit of effort of the different size groups for the three years from 1961-62 to 1963-64.

Banerji and George (1967) have shown that M. dobsoni reaches a size of about 95 mm at the end of one year and about 115 mm at the end of the second year of its life. Taking this as the basis, the relative abundance of the various age groups of M. dobsoni for the three fishing seasons from 1961-62 to 1963-64 are given in the following table:

TABLE II

Relative abundance of various age groups in different seasons

	0-year	1-year	2-year
1961-62	3393	3255	324
1962-63	2010	928	59
1963-64	887	453	27

In the above table, the relative abundance of 0-year class may be an underestimate since prawns of small size may have escaped, but for the purpose of this calculation the same may be ignored.

It is well known that

$$N_t = N_o e^{-(F+M)t}$$

where N_t is the number of fish of any age t and N_o is the initial number of fish at 0 age and (F+M) is the total annual instantaneous mortality rate. The above equation can be rewritten as

$$\log_e N_t = \log_e N_o - (F+M)t$$

$$= A+Bt$$

showing a linear relation between $\log_e N_t$ and t. Thus if a linear regression is fitted between $\log_e N_t$ and t, the slope $B = -(F+M)$ can be determined which will furnish an estimate of (F+M). From Table II, we have the following data:

t	$\log_e N_t$
0	$\log_e 3393$
1	$\log_e 928$
2	$\log_e 27$

The slope determined for the linear regression furnishes an estimate of 2.41 for the annual instantaneous mortality rate (F+M). This is not very different from the monthly estimate of instantaneous mortality rate determined from the data of abundance in zone II in 1962 on the assumption that outward migration has ceased from April onwards.

3.2 Metapenaeus affinis

This species contributes to a good percentage of the trawl fishery of the area, whereas its percentage representation in the backwater fishery is very low, so much so, it is clear that the species utilizes the backwaters and estuaries as nursery grounds only to a limited extent. George *et al.* (in press) record two year classes for this species in the offshore fishery. Rao (MS) observed the spawning period from October to March with the peak in November-December. The bigger first-year classes dominate early in the season when the maximum catches are recorded, smaller sizes dominating later in the season (George *et al.*, in press). They have also recorded a concentration of the species in the 10 to 11 fm (18.3 to 20.1 m) contour.

3.2.1 Abundance In 1961-62 *u* in zone II ranged from 4 to 3018. An increase was observed from October onwards and the maximum was reached in May. In zone III the minimum of 85 was recorded in April, while the maximum of 1823 was in March. In January and February there was no fishing in this zone. In February, when there was fishing in zone IV, *u* was as high as 1031 (Fig. 3).

In 1962-63, there was fishing in zone I in November only, when *u* was 210. In zone II *u* varied between 348 and 1779, the catch being higher in the early half of the season. In zone III in May *u* was unusually high, being 1233. In zone IV, fishing was carried out in October-November and June and *u* was quite high in October and June. Fishing was conducted in zone V in September and October. In the latter month *u* was 223.

In 1963-64 *u* was quite insignificant in zone I when there was fishing in October-November. In zone II *u* ranged from 27 to 812, the former in October and the latter in December, and in zone III *u* varied from 216 to 1183. There was no fishing operation in zone V.

In general there was steady increase in *u* in the first half of the season with reduction later.

3.2.2 *Size* In zone II the maximum *m* ranged between 130.9 and 132.6 in the first half of the season and the minimum between 90.6 and 94.5 in the later half, this being true of the three seasons in 1961-64. In zone III also similar trend was noticed. Here the maximum ranged from 129.9 to 137.0 and minimum from 83.4 to 101.0. In zone IV, where there were operations in a few months, *m* varied between 113.5 and 125.8. In general, the size increased steadily in the early half of the season and later declined. In these years *r* ranged between 46-135 and 86-165.

3.2.3 *Movements* In the first season from October to January both *u* and *m* showed increase in zone II indicating influx of new groups of prawns of bigger sizes into the zone. The data from zone III, which is relatively deeper and adjoining the previous one, also showed similar increase from October to December indicating influx of new populations of bigger sizes into this zone also. The value of *m* remained above 130 in zone III in all these months, whereas, that size was attained only in December-January in zone II. In the month of February, both *u* and *m* fell in zone II, showing movement of bigger sizes out of the area. The *r* during this month was between 56-145 as compared to 76-160 during the previous month. This would suggest egression of larger sized prawns and incursion of smaller ones in the zone. The direction of movement of these big prawns becomes clear when the simultaneous increase in abundance of the larger prawns in zone IV is taken into account, showing that they were moving offshore. In March, *u* increased considerably in zone II, while *m* showed only slight increase; and in zone III, *u* increased while *m* decreased, obviously due to the entry of small sized prawns into both these zones. The slight increase in mean size in zone II could have been due to the migration of the very small prawns to zone III, or to natural growth. In the following month both *u* and *m* registered decline in both these zones. The *r* showed that prawns above 135 were not at all seen in these zones. This meant that on the one hand big sized prawns had completely moved away while on the other hand the offshore migration of small prawns continued. In May, however, the same trend continued showing fresh incursion of small sized prawns from the inshore areas into this zone. The smaller prawns which entered zones II and III in May moved out into the deeper zones as evident from the lower values of *u* and *m*. This is corroborated by the high value of *u* and low *m* recorded in zone III during this month.

The data for the next two seasons also showed the same type of movement with minor differences in the time of commencement and ending of these movements. The general picture that emerges is that shoreward movement of big sized prawns commences in October or even earlier, and from February both big sized as well as small sized prawns begin to move outward into the offshore regions. By about June no big prawns are seen up to 15 fm (27.5 m) area.

3.3 *Penaeus indicus*

Certain biological aspects of the fishery of this species in the region have been elucidated by the studies of Menon (1957), George (1961; 1962a; 1962b), Menon and Raman (1961), George *et al.*(in press) and Rao (MS). The juveniles of this species contribute to a good fishery in the backwaters. In the marine environment the spawning period of the species, according to George (1962a) and Rao (MS), is prolonged from October to May with two peaks, one during February to April and the other in November-December. The size composition in the trawl fishery is given by George *et al.* (in press) and according to them three year classes are represented in the catches.

3.3.1 Abundance In the 1961-62 season zone I was fished only in September-October and the value of u was very low. In zone II u varied from 19 to 732, the minimum in April and maximum in February. From November to January operations in zone III gave values of u between 165 and 376. In zone IV there was fishing only in February when u was recorded as 33 (Fig. 4).

Between November and April in 1962-63, u ranged from 3 to 486 in zone II, the maximum being in December; and in zone III fishing was almost nil except in November when u was quite insignificant. A high value of 1296 u was recorded in June from zone IV.

In the 1963-64 season u remained comparatively low, varying between 5 and 148, in all the months and in all the depth zones.

3.3.2 Size In 1961-62, m ranged between 105.5 and 170.0 in zone II from December to June, the lowest being in April and the highest in January. In zone III from November to January m remained quite high, above 170.0, and in March it was as low as 133.7. In the next deeper area, zone IV, there was fishing only in February, when m was 159. In 1962-63, in zone II the range of m was between 121.7 and 168.0, the latter in November. In a few operations in the deeper zones m varied between 143.0 and 154.3. Range of r was from 96-135 to 151-185.

3.3.3 Movements The data in respect of this species is insufficient to trace the movements fully. However, from February to April in 1961-62, in zone II, both u and m declined, indicating that big prawns of the species were moving out of the area. Similarly, both u and m were seen decreasing in the succeeding years also in the same depth zone. In 1963-64 from January to March, in zone III, both u and m were seen declining, i.e., the big prawns were moving out of this area also. In February 1963-64 no prawns of size larger than 135 mm were found in zone II, but at the same time in zone III prawns up to 190 mm were seen, and by March, prawns larger than 160 mm size were also noticed. But, prawns of 181-190 r were seen in the same month in zone IV. This leaves no doubt that bigger size prawns were moving offshore during December-February. Towards the latter half of the season it was generally seen that smaller sizes were recruited into these zones and they in turn moved out to deeper areas. In 1963-64, during the period February-April, u increased while m decreased in zone II indicating thereby that smaller sized prawns were moving into the zone. In 1962-63 during the same period u decreased while m showed an increase, indicating that small sizes were moving out of the zone. In 1961-62, however, these movements of the smaller sizes took place much later in the season, during April to June.

3.4 Metapenaeus monoceros

Juveniles of this species contribute to the backwater fishery of the area more than to the inshore fishery. Knowledge about the biology and fishery of this species is limited to the studies by George (1959; 1962a), Menon and Raman (1961), George and George (1964) and George et al. (in press). The 0-year class contribute to the backwater fishery. According to George (1959) three year classes are represented in the mechanized fishery around Cochin, the bigger year classes coming into the fishery in November-December and the smaller sizes appearing later. It is noted that in some years the bigger sizes fail to appear in the fishery.

3.4.1. Abundance The species was caught only in a few months in the first two years, in zone II. Value of u was not high in April and May. In zone III u varied from 1 to 297 in these years. In 1962-63, there were comparatively higher values of u ranging from 47 to 1622 in the deeper zones IV and V in September-October (Fig. 5).

In 1963-64 in zone II the maximum u of 203 was recorded in December and in July it was at the minimum of 2. In zone III, u ranged between 24 in February and 467 in May. Generally, an increase in u was noticed in the earlier months with decline later.

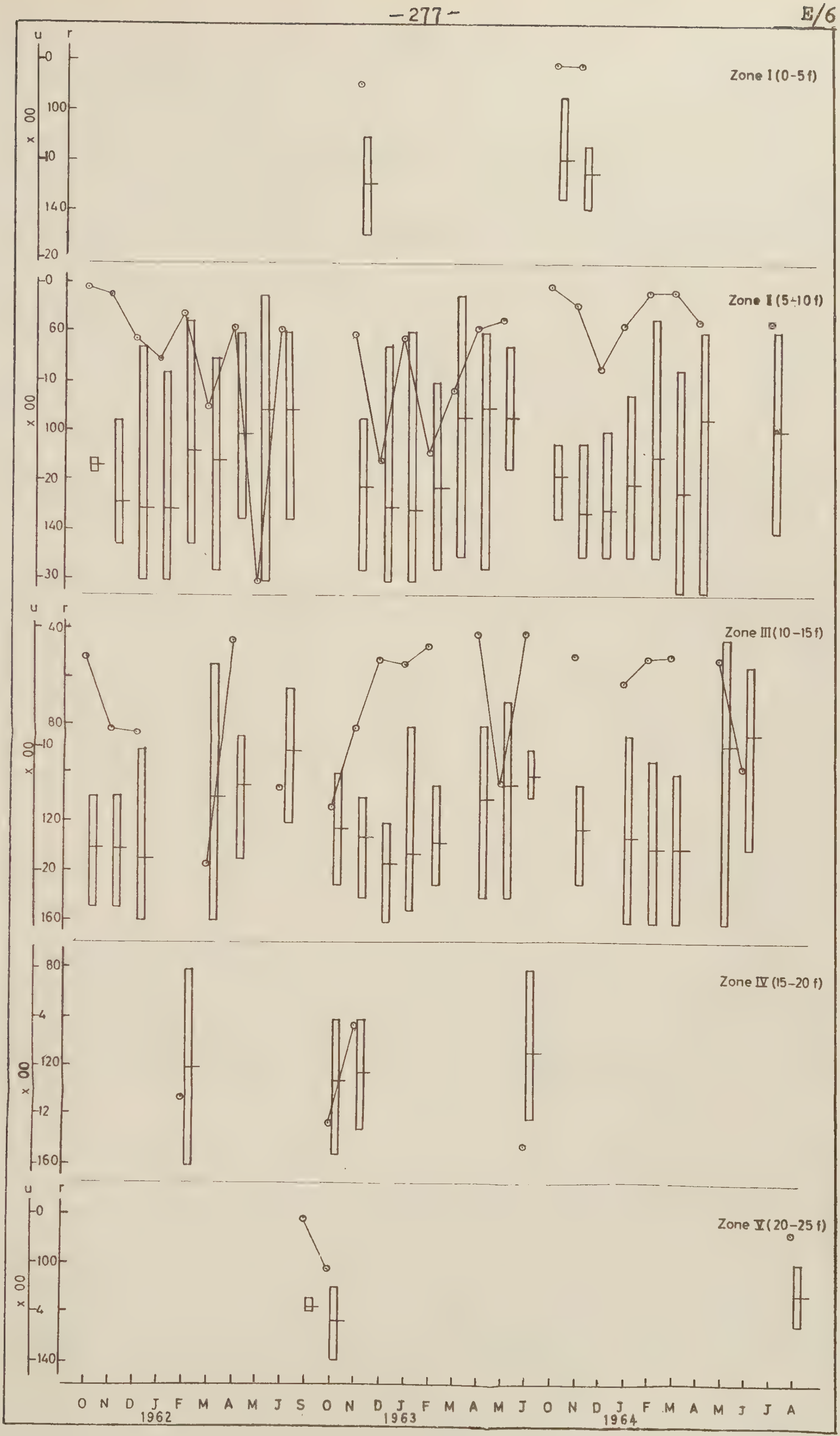

Fig. 3 Abundance and size of *M. affinis* during 1961-62 to 1963-64. Vertical column represents size range (r) and horizontal line on it the mean size in mm. Abundance (u) in number per trawling hour.

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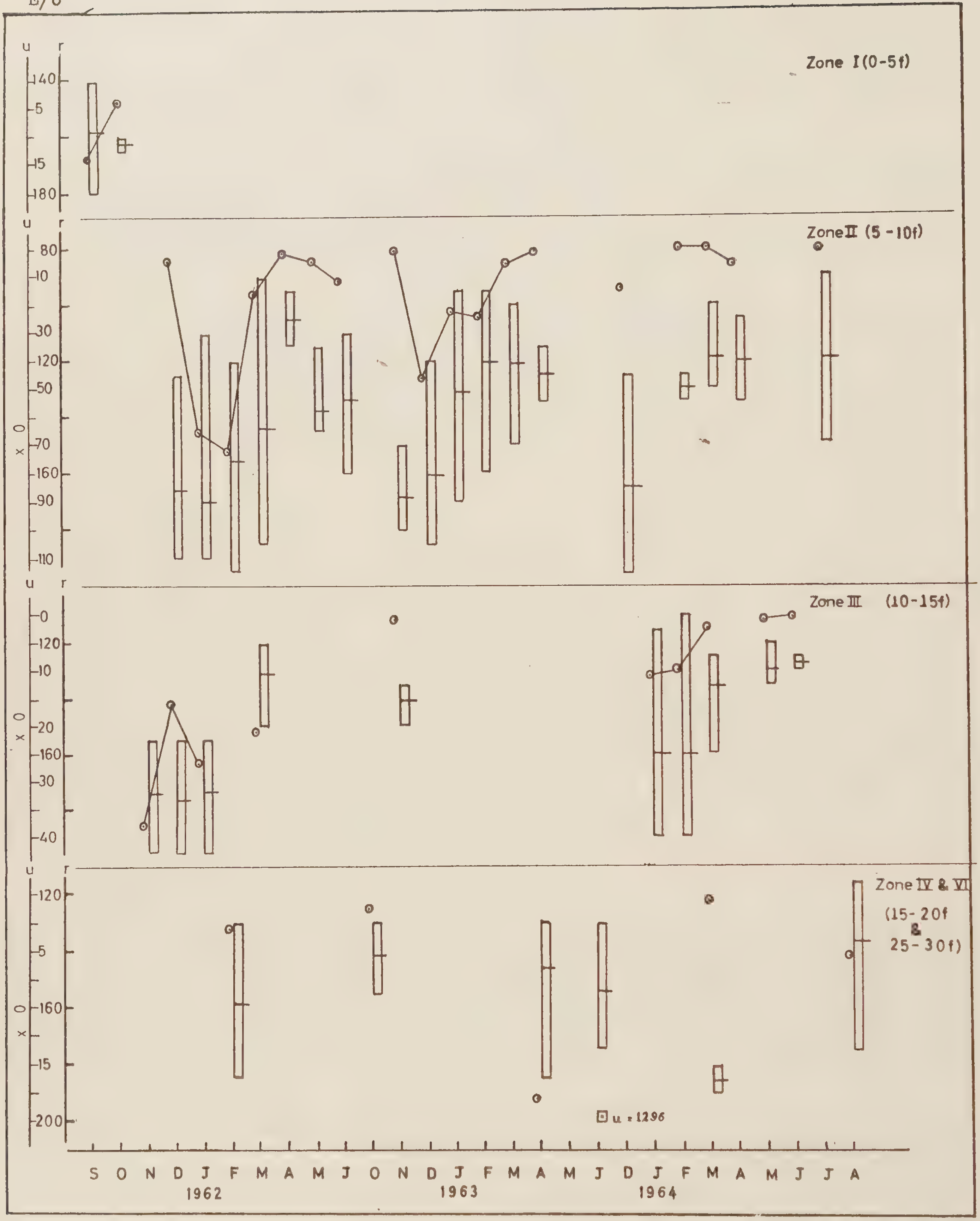

Fig. 4 Abundance and size of P. indicus during 1961-62 to 1963-64. Vertical column represents size range (r) and horizontal line on it the mean size in mm. Abundance (u) in number per trawling hour.

3.4.2 Size In the limited catches of zone II, m ranged between 74.6 and 120.5 in the first two years with mostly the smaller sizes being caught in April and May. In zone III, m varied between 88 and 143 and in zone IV, the maximum m of 168.0 was recorded in November. In 1963-64, in zone II, m was recorded at the maximum of 128.0 in November and the minimum of 63.0 in February. In zone III, m was at the maximum value of 135.0 in January and the minimum of 78.0 in June. In zone IV, there was catch only in March when m was 150.5. The size range, r, was between 51-90 and 166-175.

3.4.3 Movements Taking the data of the first year into consideration, in zone II, from January to May there was slow increase in u along with a fall in m, indicating that during these months smaller sized prawns entered the zone though not in large numbers. In zone III, between January and April, u was declining along with m, showing gradual exodus of bigger prawns from the zone to deeper regions, and in zone IV, prawns of sizes above 86 mm only were seen in February. The migration pattern seems to be size related. By about May only prawns up to 90 mm size remained in zones II and III, while bigger prawns moved further offshore. In 1962-63, although not much data were available, it could be seen that in September-November big sized specimens were present in zones IV and V, and in April-May small sized specimens were found in zones II and III. In November-December of the following year, in zone II, u increased while m fell slightly, indicating influx of new groups of smaller sizes. The size ranges showed that prawns of 80 to 95 mm size have entered this zone. Next month both u and m declined as bigger prawns above 150 mm moved out of zone II. By February prawns bigger than 65 mm have all left the area as indicated by r. But for a slight increase of m in March, during the remaining months only small sized prawns were present in this zone. In zone III both u and m increased from November to January showing influx of bigger prawns. It is already seen that sizes above 150 mm left zone II in January, obviously for zone III. In February, u and m decreased, showing departures of bigger specimens from here. In the next month, u was noticed to increase while m fell, indicating the entrance of some smaller prawns into zone III; and by about June, prawns bigger than 95 mm had left this zone.

In general, the offshore migration commenced from November and by about April all prawns greater than 80 mm size moved out of zone II. By June the prawns above 95 mm size moved out of the deeper zone III also. In still deeper waters prawns of larger sizes only were encountered.

3.5 Parapenaeopsis stylifera

Among the five species of penaeids contributing to the prawn fishery of the region, the behaviour of this species is unique, as the postlarvae of this alone do not enter the backwaters. The fishery is limited to the marine environment. Some aspects of the biology and fishery of the species have been studied by Menon (1953: 1957) and George (1961). George et al. (in press) found two year classes represented in the trawl fishery off Cochin.

3.5.1 Abundance Very early in the season small quantities of this species with comparatively low values for u were found in zone I in all the three years. In 1961-62, u ranged between 124 and 2609 in zone II, with the maximum in October and the minimum in January. Very high values of u, above 2000, were recorded in May and June. In zone III, u varied from 11 in December to 2845 in June, and it was fairly high in September-October in zones IV and V (Fig. 6).

In the next year, a maximum u of 1036 was recorded in December and the minimum of 76 was in May, in zone II. Very high values of u viz., 4030 and 1598 were obtained in October and November, from zone III. The maximum abundance of 10846 u was recorded in September from the deeper area, zone V. In zone IV, u was very high in June.

In zone II, u varied between 210 and 997 from December to May, 1963-64, and was significantly high in zone III, in June, being 3667. In zone V there was significant catch with u at 1473 in October only.

3.5.2 Size The trend in size variations was quite similar in all the three years. In zone II, in all the years, m increased gradually and reached the maximum of 90.2 to 95.3 by January-February and then declined. In zone III, in 1963-64, a maximum of 113.0 m was recorded in February. In zones IV and V m was comparatively lower, ranging from 77.2 to 90.0.

3.5.3 Movements Although mean size m showed a regular pattern in all the years, abundance did not give any dependable trend. In 1961-62, in zone II, there was decrease in m along with increase in u in April-June which indicated entry of small sized prawns into the area. In 1963-64, from October to December there was increase in u along with increase in m showing incursion of bigger sized prawns into this zone. In 1962-63, from March to May both u and m were noticed declining, indicating movement of bigger sized prawns away from zone II.

Apart from these, no clear pattern of movement could be discerned from the variations in u and m.

4 DISCUSSION

The foregoing account provides a general picture of the nature of fluctuations in abundance (u) and mean size (m) of the commercially important penaeids of this region. The pattern of movements of prawns in the fishing grounds is shown to be size-oriented and this is true of all the species dealt with. Soon after the monsoon, when the fishery commences, large sized prawns are seen to move into the fishing grounds which are at that time mostly confined to zones II and III. This movement, from adjoining deeper zones, is probably a sort of recolonization of the grounds, the prawns having deserted them earlier during the physico-chemical disturbances brought about by the monsoon and the upwelling. It is, therefore, apparent that the effect of upwelling during the monsoon (Banse, 1959) is to drive all the species of prawns, except M. dobsoni, into the deeper waters. The available information does not indicate up to what depth these prawns are pushed out, or at what level they remain during this period. This phenomenon, coupled with decrease of fishing effort during the period, results in the increase of mean size which is evident at the commencement of the fishery. The better catches of prawns obtained by a few well equipped trawlers from the deeper waters operating from Cochin during monsoon lend additional support to this view. The offshore movement of these prawns from January onwards, particularly of the larger species, P. indicus, M. affinis and M. monoceros, indicate prospects of better yield if trawling is carried out in deeper waters towards the end of the season also.

While tracing the movements of these prawns in the fishing grounds, it becomes necessary to examine the possibility of their coastwise movement. The pattern of distribution of size and abundance of all the species brought out here clearly indicates movements from one depth zone to the other. In a dynamic population some coastwise movement can naturally be expected although the present data do not seem to give any indication of the same in the depth zones considered. Extensive marking experiments only can bring out conclusive evidence in this respect. The detailed marking projects carried out on the white shrimp Penaeus setiferus showed no indication of coastwise migration along the major portion of the Gulf of Mexico (Lindner and Anderson, 1956).

The distribution of abundance over the three years of observation show a decreasing trend, particularly in zone II, (Figs. 2 - 6) where the maximum exploitation is taking place at present. George et al. (in press) observed decreases in abundance in the same fishery from 1958-59 onwards, but the unusually large catches in 1961-62 made them attribute this to natural fluctuations. Here the trend is continued in the next season also, as shown by the present study, and may well be attributed to natural fluctuations, especially when the rate of instantaneous mortality of the major constituent of the fishery, M. dobsoni, is estimated as being very low (Banerji and George, in press). A more or less similar trend was observed in the yield of shrimps of Sanibel-Tortugas areas by Kutkuhn (1960) during 1956-59. Examination of related data over a protracted period concerning the same fishery enabled Eldred et al. (1961) to attribute this declining tendency to natural fluctuations.

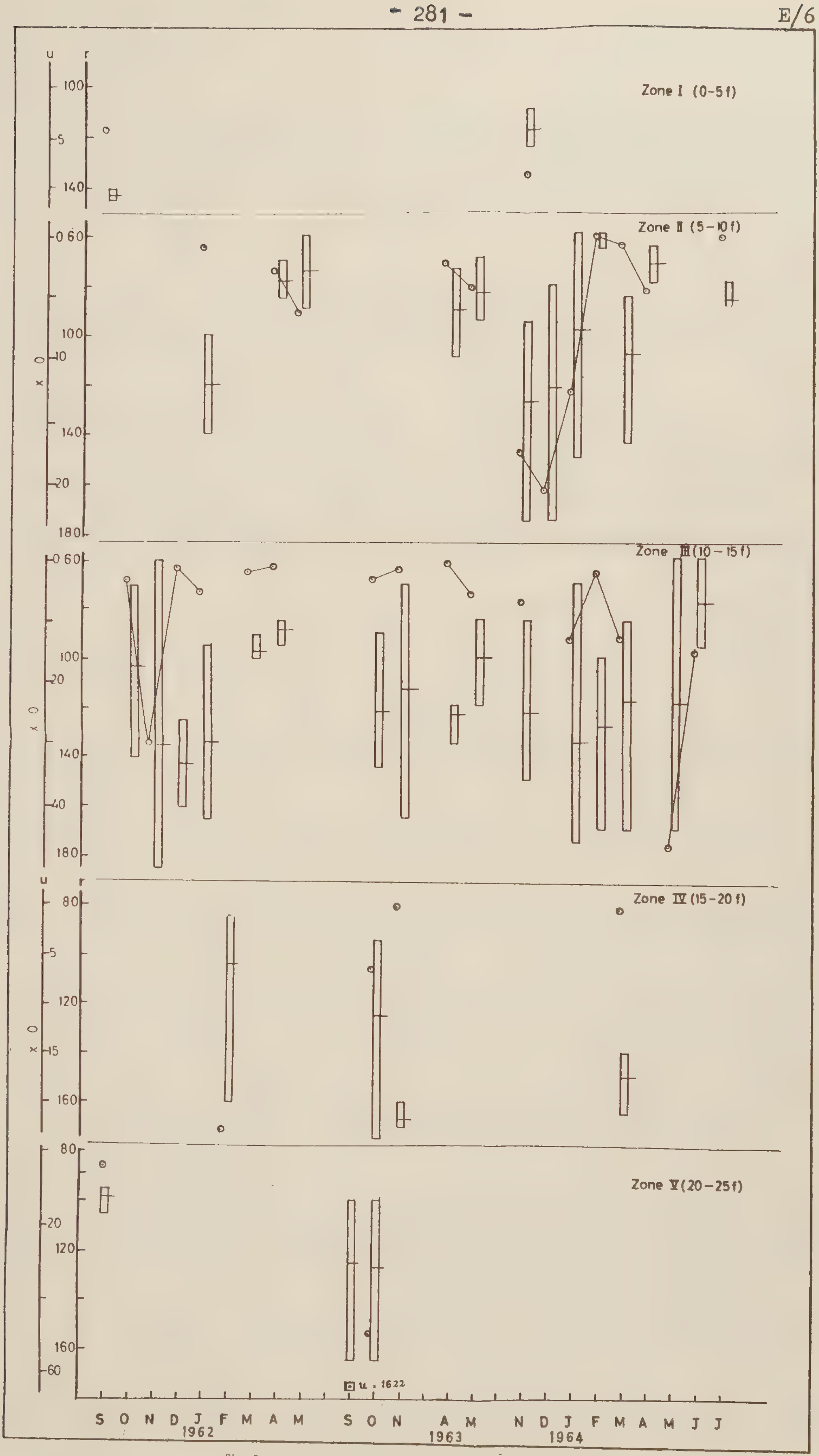

Fig. 5 Abundance and size of M. monoceros during 1961-62 to 1963-64. Vertical column represents size range (r) and horizontal line on it the mean size in mm. Abundance (u) in number per trawling hour.

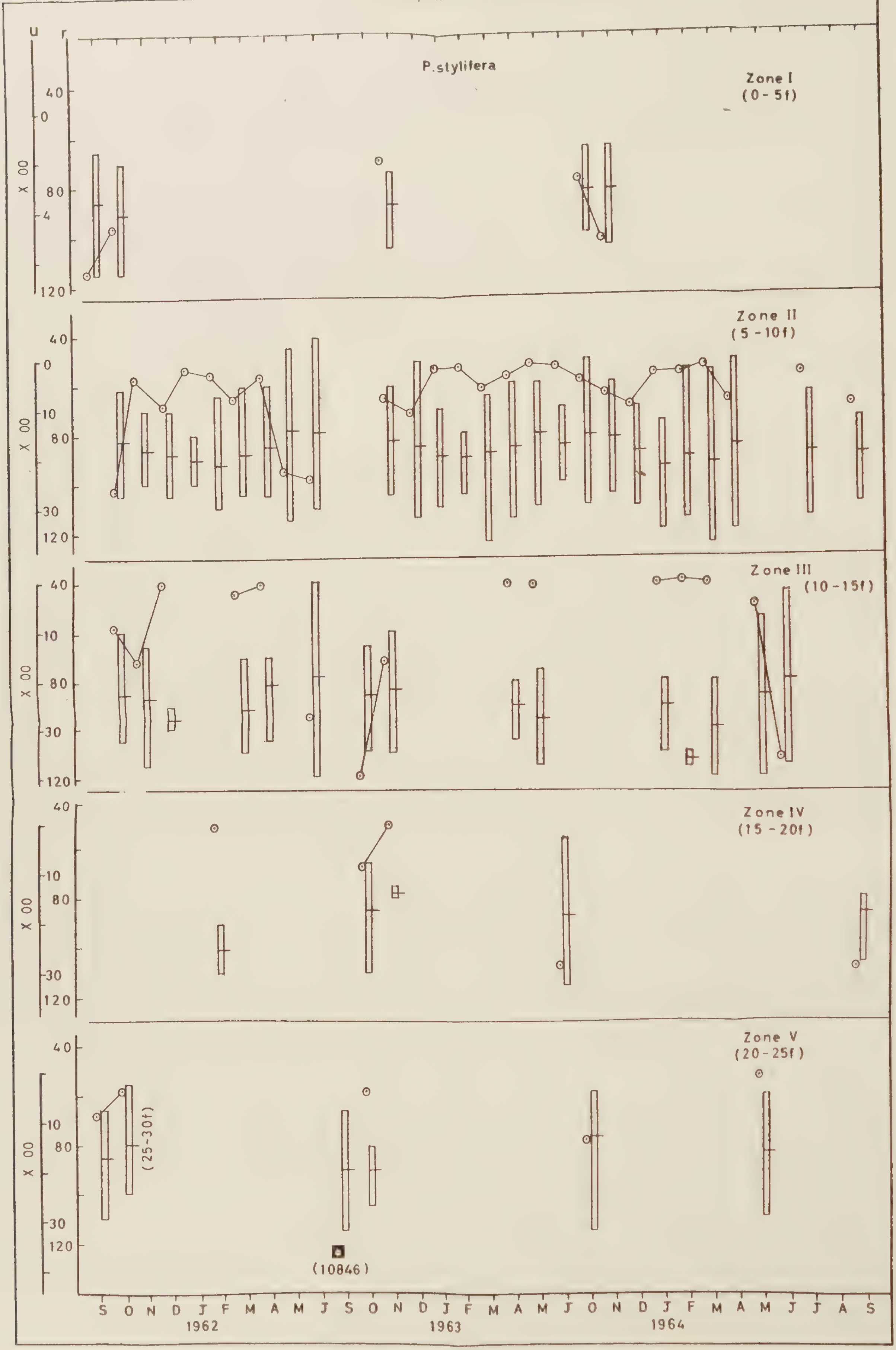

Fig. 6 Abundance and size of P. stylifera during 1961-62 to 1963-64. Vertical column represents size range (r) and horisontal line on it the mean size in mm. Abundance (u) in number per trawling hour.

Nevertheless, this declining trend may cause apprehensions to the industry and has to be very carefully watched. The distribution of fishing effort, which is now concentrated in zone II where this trend is particularly evident, may be advantageously directed to the deeper zones where the possibility of better yield of large sized prawns exists as pointed out here.

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* * * *

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MATURATION AND SPAWNING OF THE PENAEID PRAWNS OF THE SOUTHWEST COAST OF INDIA

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Abstract

Some aspects of the maturation and spawning of the commercially important prawns of the southwest coast of India, *Metapenaeus dobsoni*, *M. affinis*, *Penaeus indicus* and *Parapenaeopsis stylifera* have been studied.

In all the species the mature ovary consists of anterior, middle and posterior lobes. Five maturity stages: immature, early maturing, late maturing, mature and spent-recovering stages are distinguished and the maturation process in the female of each species is described. The minimum size at first maturity was estimated to be 64.1 mm for *M. dobsoni*, 88.6 mm for *M. affinis*, 130.2 mm for *P. indicus* and 63.2 mm for *P. stylifera*. *M. dobsoni* and *P. stylifera* breed throughout the year, with peaks in June, November-December and April, while in *P. indicus* and *M. affinis* the breeding period extends over the period from October to March or April. The spawning of individual prawns of each species is restricted to short and definite periods, as shown by ova diameter studies, and individuals are estimated to spawn five times during their lifetime. Highest spawning activity was observed when the water temperature was relatively high. The relationship between length of prawn and fecundity was found to be logarithmic in all the species.

MATURATION ET REPRODUCTION DES PENAEIDAE DE LA COTE SUD-OUEST DE L'INDE

Résumé

La communication étudie certains aspects de la maturation et de la ponte des crevettes d'importance commerciale de la côte sud-ouest de l'Inde : *Metapenaeus dobsoni*, *M. affinis*, *Penaeus indicus* et *Parapenaeopsis stylifera*.

Dans toutes les espèces étudiées, l'ovaire mûr comprend un lobe antérieur, un lobe moyen et un lobe postérieur. On distingue cinq stades de maturité : immature, début de l'évolution, fin de l'évolution, fin de l'évolution, mature et post-ponte (récupération), et l'auteur décrit le processus de maturation chez la femelle de chaque espèce. Estimation des tailles minimales à la première maturation : 64,1 mm pour *M. dobsoni*, 88,6 mm pour *M. affinis*, 130,2 mm pour *P. indicus* et 63,2 mm pour *P. stylifera*. *M. dobsoni* et *P. stylifera* se reproduisent toute l'année, avec des pointes en juin, novembre-décembre et avril, tandis que chez *P. indicus* et *M. affinis*, la période de reproduction s'étend d'octobre à mars ou avril. La ponte des individus de chaque espèce est limitée à des périodes brèves et bien définies, comme l'a révélé l'étude du diamètre des oeufs, et l'on estime que les individus pondent 5 fois durant leur vie. On a observé le maximum d'activité reproductrice lorsque la température du substrat était relativement élevée. Pour toutes les espèces, le rapport entre la longueur de la crevette et la fécondité s'exprime sous forme logarithmique linéaire.

MADURACION Y DESOVE DE LOS PENEIDOS DE LA COSTA SUDOCCIDENTAL DE LA INDIA

Extracto

Se han estudiado algunos aspectos de la maduración y desove de los camarones de importancia comercial de la costa sudoccidental de la India, a saber: *Metapenaeus dobsoni*, *M. affinis*, *Penaeus indicus* y *Parapenaeopsis stylifera*.

En todas las especies, el ovario maduro consta de lóbulos anterior, medio y posterior. Se distinguen cinco fases de madurez: inmaduros, en principios de maduración, maduración avanzada, maduros, frezados en recuperación, y se describe el proceso de maduración en la hembra de cada especie. La talla mínima en la primera madurez se ha calculado en 64,1 mm para *M. dobsoni*; 88.6 mm para *M. affinis*, 130,2 mm para *P. indicus* y 63,2 mm para *P. stylifera*. *M. dobsoni* y *P. stylifera* crían durante todo el año con máximos en junio, noviembre-diciembre y abril; *P. indicus* y *M. affinis* lo hacen durante un largo período que se extiende de octubre a marzo o abril. El desove de los camarones individuales de cada especie se limita a períodos breves y definidos, como han relevado los estudios del diámetro de los huevos, y se calcula que desovan cinco veces durante su siclo vital. La mayor actividad de desove se ha observado cuando la temperatura del sustrato es relativamente alta. Se ha descubierto que la relación existente entre la longitud y la fecundidad del camarón adopta una forma logarítmica lineal en todas las especies.

1 INTRODUCTION

Studies on the breeding habits of some Indian penaeid prawns have been carried out by Menon (1952; 1953), Shaikmahmud and Tembe (1960; 1961), Rajyalakshmi (1961), George (1962) and Subrahmanyam (1963). Most of these investigations were restricted to the determination of the time of spawning, and the conclusions arrived at were based entirely on the data on incidence of mature prawns in the catches obtained in different months. No detailed study on the process of maturation, spawning periodicities and the factors influencing successful spawning, have been so far attempted. The present investigation pertains to the study of different aspects of spawning of four commercially important species of prawn in the Cochin area: Metapenaeus dobsoni (Miers), M. affinis (H. Milne Edwards), Penaeus indicus H. Milne Edwards and Parapenaeopsis stylifera (H. Milne Edwards).

2 MATERIAL AND METHOD

From June 1963, regular samples of prawns were collected from the catches of commercial fishing boats operating off Cochin at depths of 9 to 36 m. These samples were sorted into species and their lengths, from tip of rostrum to tip of telson, were recorded separately for both sexes. Observations on the nature, colour, size and texture of ovaries, indicating the degree of maturity, were also recorded. On the basis of these, the season of highest spawning activity was determined, when the highest frequency of 'light green' and 'dark green' ovaries occur.

Diameters of ova were determined from ovaries hardened in 5 percent formaldehyde for at least two days, using a compound microscope with an ocular micrometer. The diameters were taken parallel to the ocular micrometer in order to avoid errors due to selection, and distortion in preservation.

Preliminary observations did not indicate differential development of ova in the various parts of the ovary. For the purpose of this study, however, samples were taken from the middle lobe only and 300 ova were measured from each ovary.

The fecundity, or total number of ova in a mature ovary, was calculated from the weight of the ovary and the number of eggs in a weighed subsample.

3 THE OVARY

Shaikmahmud and Tembe (1958) have described the anatomy and histology of the male and female reproductive organs of P. stylifera. The general shape and appearance of the ovaries are similar in all the four species studied, and also agree with the descriptions of the ovaries of Penaeus setiferus by King (1948) and P. duorarum by Cummings (1961). The mature ovaries are paired organs, situated dorsally, extending from the base of the rostrum to the last abdominal segment. They are bilaterally symmetrical and partly fused. Each half of the ovary consists of three lobes, of which the slender anterior lobe occupies the anterior region. The middle lobe has 6 or 7 finger-like lateral lobules which entirely fill the area between the anterior region and the posterior border of the carapace. The posterior lobes extend the length of the abdomen. The two halves of the ovary are united by two commissures, one at the base of the anterior lobes and the other at the tip of the posterior lobes in the 6th abdominal segment (Fig. 1).

4 MATURATION

There is little consistency among the various workers who have studied the maturation of ovaries in prawns as to the number of steps of maturity recognized. Thus, King (1948) recorded five stages in Penaeus setiferus, and Cummings (1961) described only four in P. duorarum. Shaikmahmud and Tembe (1961) differentiated between spent and regenerating P. stylifera, to give six stages, but Rajyalakshmi (1961) included neither spent nor regenerating stages among the five which she recognized for Macrobrachium rosenbergii and M. mirabile (as Palaemon carcinus and P. mirabilis respectively). Renfro and Brusher (1964) classified the developmental stages of white shrimp (Penaeus setiferus) into seven stages, and recently Oka and Shirhata (1965) recognized eight maturity stages

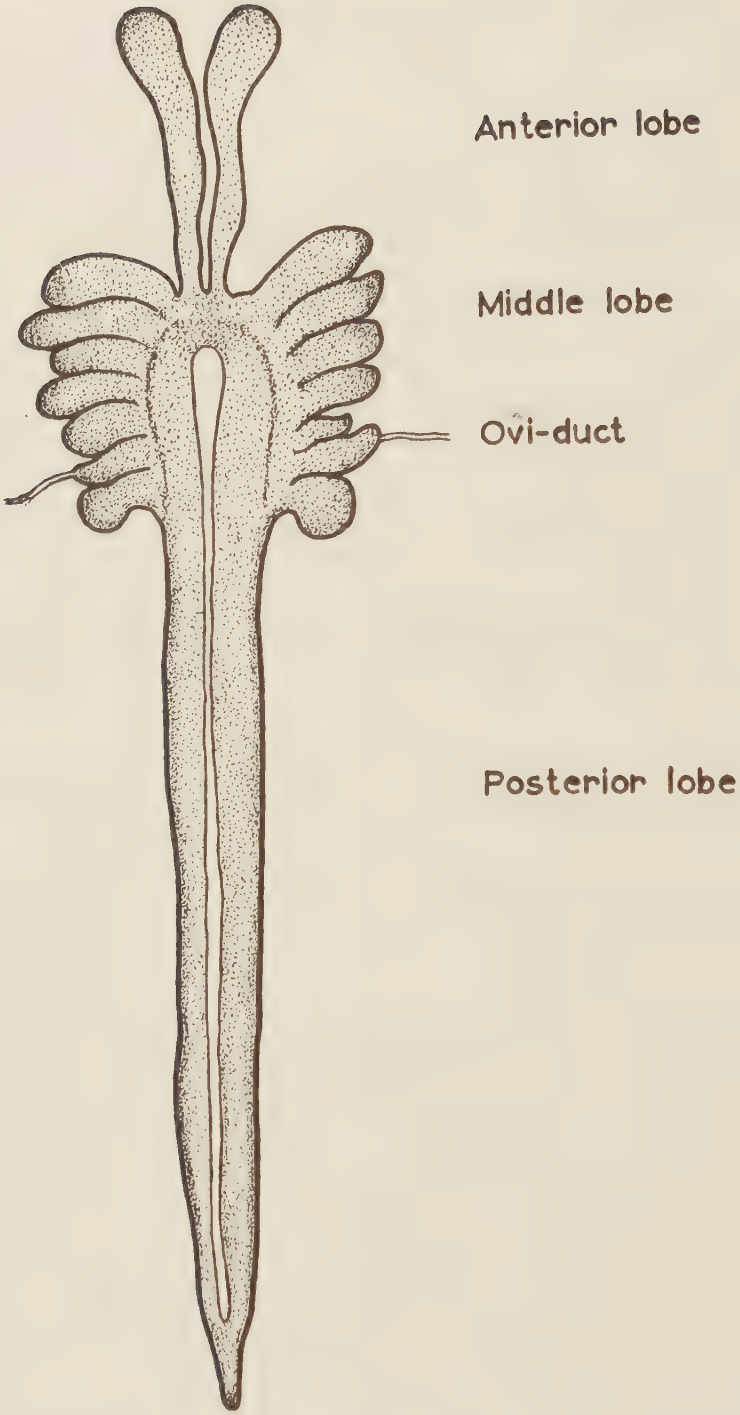

Fig. 1 Mature ovary of a typical penaeid prawn, showing the different regions.

in Penaeus orientalis.

Five maturation stages are recognized for the four species of Penaeidae covered by the present paper, and they may be distinguished on the following points:

Immature stage: The ovaries of immature prawns are thin, translucent, unpigmented and confined to the abdomen. They contain oocytes and small spherical ova with clear cytoplasm and conspicuous nuclei.

Early maturing stage: The ovary is increasing in size and the anterior and middle lobes are developing. The dorsal surface is light yellow to yellowish green. Opaque yolk granules are formed in the cytoplasm and partly obscure the nuclei. The developing ova are clearly larger than the immature stock.

Late maturing stage: The ovary is light green and is visible through exoskeleton. The anterior and middle lobes are fully developed. The maturing ova are opaque, due to the accumulation of yolk.

Mature stage: The ovary is dark green and clearly visible through the exoskeleton. The ova are larger than in the preceding stage and the peripheral region becomes transparent. This stage is believed to be the last stage of maturity before actual spawning as the largest ova are encountered only in this stage. Further confirmation is available in M. dobsoni, in which the diameters of the ova in this stage are very close to those of the planktonic eggs (Menon, 1952).

In mature eggs of P. indicus rod-like peripheral bodies radiate from the opaque central region. The presence of these peripheral bodies in the mature ova has not been observed in the other three species; it is considered to be a characteristic feature of the final stage before spawning in several other species of Penaeus (Hudinaga, 1942; King, 1948; Cummings, 1961).

Spent-recovering: It is probable that after the extrusion of eggs, the gonad revert almost immediately to the immature condition. The present stage is therefore distinguishable from that found in immature virgin females only on the size of the prawn (see section 5).

The size distributions of ova at various stages during maturation for each of the four species are given in Figs. 2 to 5. These figures help to emphasize that growth of eggs is a continuous process and that the subdivision of this process into maturation stages is arbitrary. These data are summarized, with respect to the five maturity stages recognized in Table I.

TABLE I

Range in diameter (mm) which includes at least 90% of the ova in each stage, for each of the four species considered

	M. dobsoni	M. affinis	P. indicus	P. stylifera
Immature	< 0.080	< 0.096	< 0.080	< 0.080
Early maturing	0.08 - 0.19	0.10 - 0.25	0.08 - 0.24	0.10 - 0.19
Late maturing	0.14 - 0.25	0.16 - 0.32	0.18 - 0.30	0.14 - 0.27
Mature	0.14 - 0.32	0.19 - 0.35	0.22 - 0.38	0.20 - 0.35
Spent-recovering	< 0.096	< 0.096	< 0.096	< 0.096

E/7

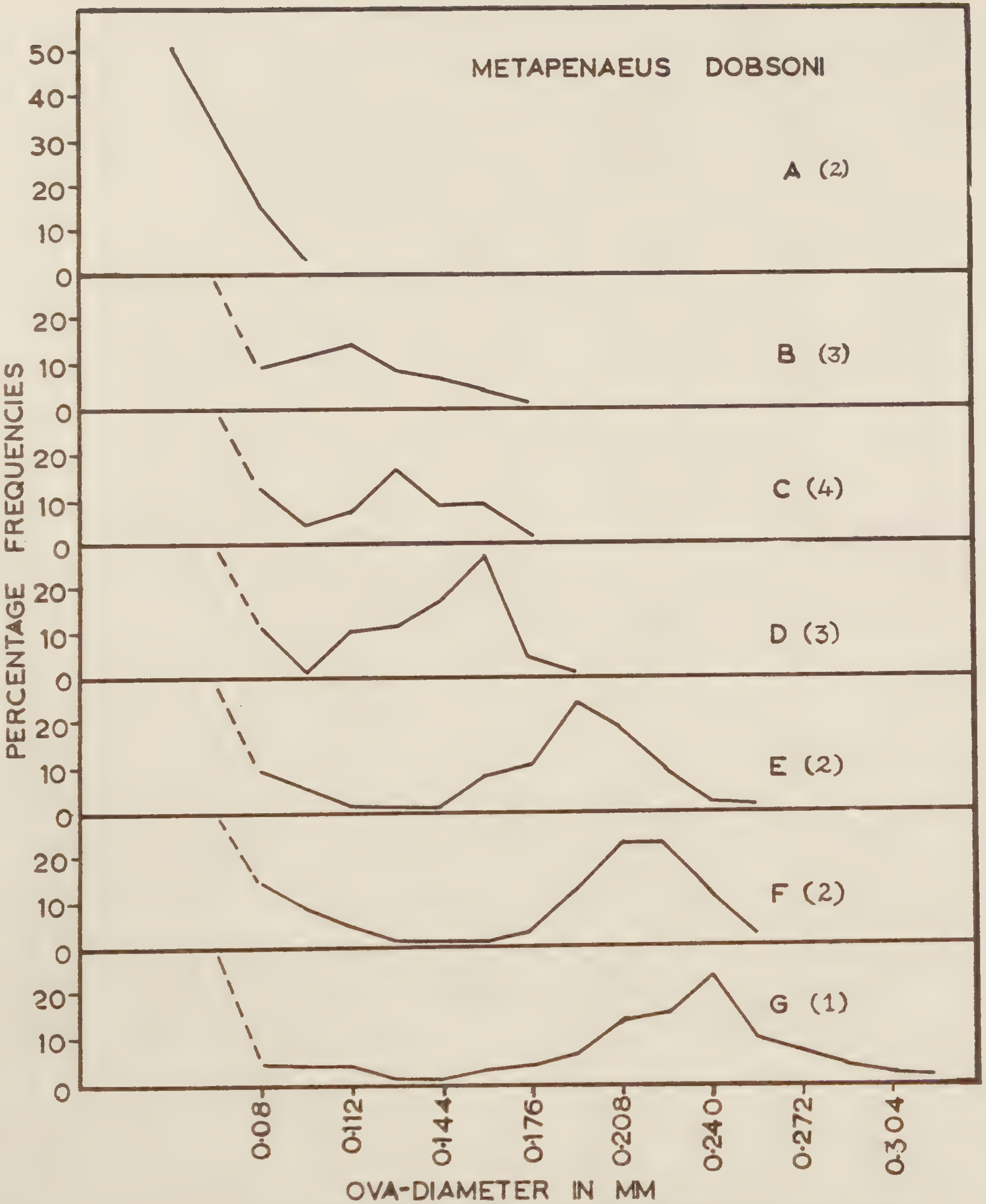

Fig. 2 Metapenaeus dobsoni: Size-frequency distribution of maturing ova. (A) Immature. (B) to (D) Early maturing. (E)(F) Late maturing. (G, Mature.
Number of specimens examined shown in brackets.

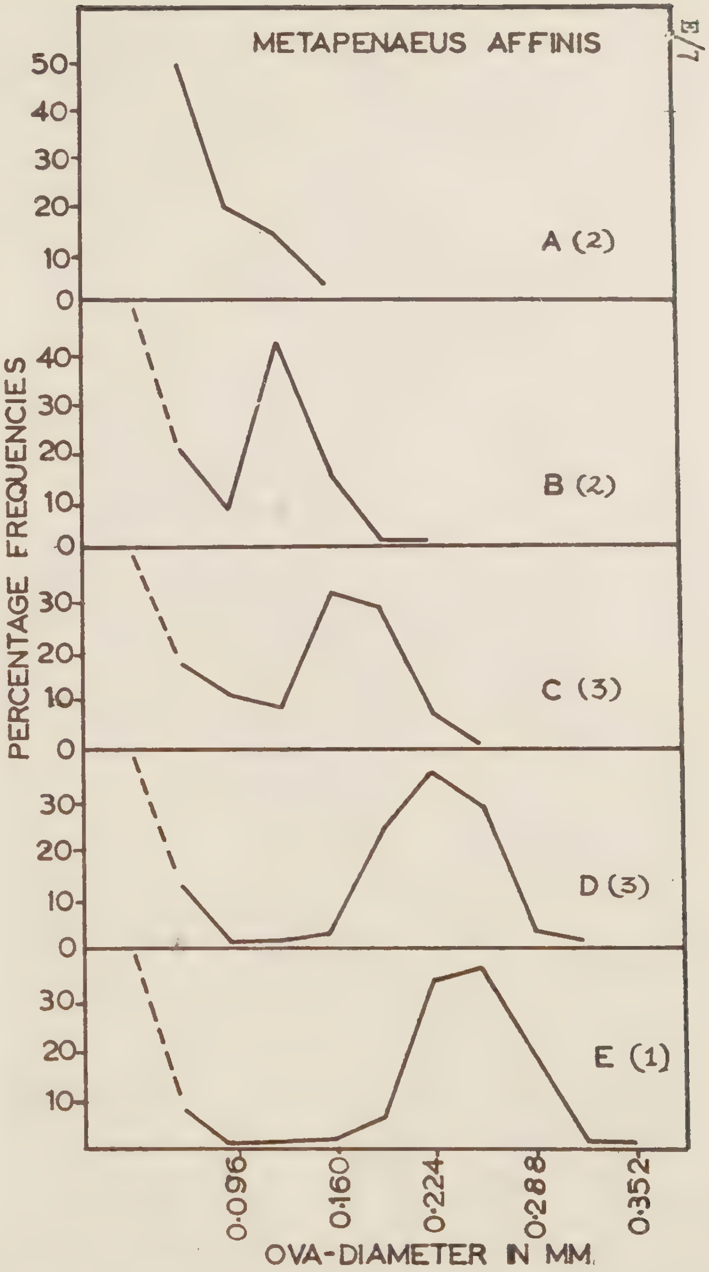

Fig. 3 Metapenaeus affinis: Size-frequency distribution of maturing ova. (A) Immature. (B)(C) Early maturing. (D) Late maturing. (E) Mature. Number of specimens examined shown in brackets.

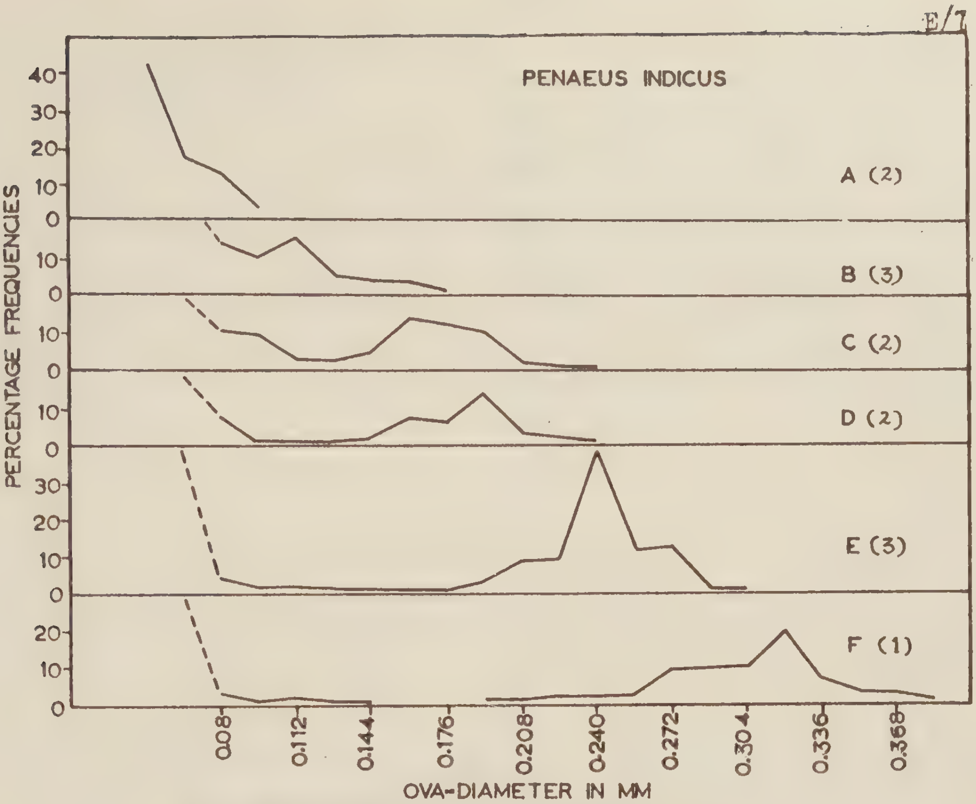

Fig. 4 Penaeus indicus: Size-frequency distribution of maturing ova. (A) Immature. (B) to (D) Early maturing. (E) Late maturing. (F) Mature. Number of specimens examined shown in brackets.

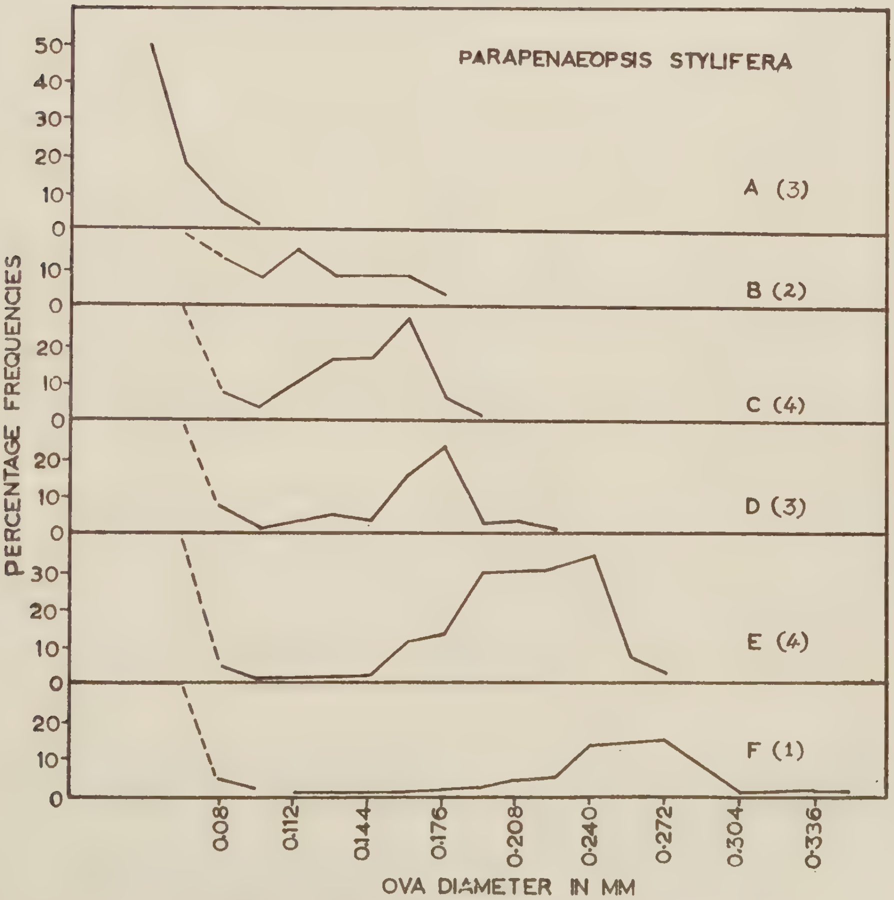

Fig. 5 Penaeopsis stylifera: Size-frequency distribution of developing ova. (A) Immature. (B)(C) Early maturing. (D)(E) Late maturing. (F) Mature. Number of specimens examined shown in brackets.

E/7

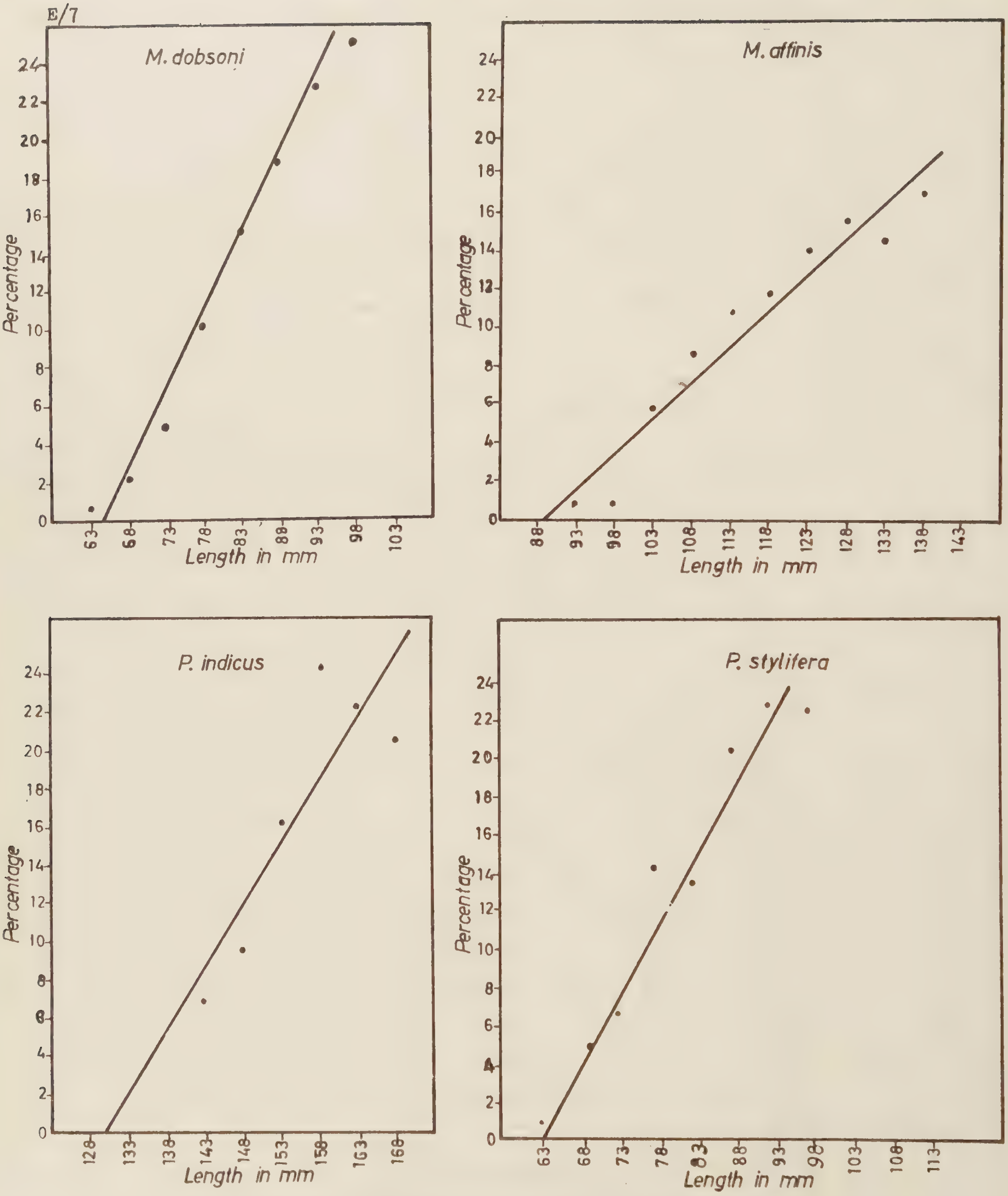

Fig. 6 Percentage of maturing and mature female prawns plotted against total length, for each species. The regression line cuts the length axis at a value corresponding to the minimum length at first maturity.

5 SIZE AT FIRST SEXUAL MATURITY

The size at first sexual maturity was determined for each species by estimating the percentages of all the maturing and mature female prawns in 12 monthly samples and plotting the length (in 5 mm groups) against the percentage of maturing and mature prawns in each size group (Fig. 6). For fitting the regression lines, only sizes up to about 100 mm for M. dobsoni and P. stylifera, up to about 140 mm for M. affinis and up to about 170 mm for P. indicus were taken into consideration. By extrapolation, the estimated minimum size at first sexual maturity was found to be 64.1 mm for M. dobsoni, 88.6 mm for M. affinis, 130.2 mm for P. indicus and 63.2 mm for P. stylifera. The smallest mature specimens of these species collected during the present study were 64, 94, 134 and 70 mm respectively, and these figures are fully consistent with the calculated minimum values.

6 SPAWNING SEASON

Present observations on M. dobsoni show that all the maturity stages are represented in all months, except in September, when immature and early maturing prawns only are encountered. The presence of late maturing and mature stages in almost all months suggests that M. dobsoni breeds throughout the year. However, peaks of spawning activity are evident in June, November to December, and April. The seasonal distribution of spawners is depicted in Fig. 7.

Menon (1952; 1955) recorded this species as breeding for at least 6 mo of the year, both on the Malabar coast and in the Cochin area, while Kesteven and Job (1957), George 1962) and George, Raman and Nair (1967) found it to breed throughout the year. It appears to be usual for the species to show two main peaks of breeding activity in the year, but the timing of these peaks may vary from place to place and from year to year.

The seasonal distribution of M. affinis in different stages of maturity (Fig. 7) shows that non-spawning prawns dominate the catches from April to September, and that the species breeds from October to March with a peak in December. George (1961) and George, Raman and Nair (1967) report the breeding time of this species as October to December in the inshore fishery and as November to February in the offshore fishery of this coast. The present observation confirms this.

The seasonal distribution of mature P. indicus is shown in Fig. 7. The species has a prolonged breeding period in Cochin waters, with the greatest breeding activity between October and April. Panikkar and Menon (1956) recorded two breeding periods, in October to November and in May to June. George (1962) and George, Raman and Nair (1967) observed that the species breeds throughout the season with spawning peaks in October to November and May to June. Subrahmanyam (1963) reports that in Madras waters, the highest breeding activity of the species is seen during March and May to September.

The seasonal distribution of mature P. stylifera (Fig. 7) shows that this species also breeds throughout the year in the Cochin area, with peaks during December and June to August. Menon (1953) has observed the breeding of the species on the Malabar coast during October to December, while Shaikmahmud and Tembe (1960) recorded the species breeding throughout the year in Bombay waters, with an intensive period in March to May. George, Raman and Nair (1967) however, observed maximum numbers of maturing and mature females in December, during the 1959 to 1960 season.

7 SPAWNING FREQUENCY

Instances of penaeid prawns spawning more than once in a season have been observed in Penaeus japonicus (Hudinaga, 1942), P. setiferus (Lindner and Anderson, 1956) and P. duorarum (Cummings, 1961). During the present investigation, the monthly distribution of late maturing and mature females of each species was studied to determine the number of spawnings in different species (Table II a,b,c,d).

TABLE II

Showing the monthly distribution (by numbers) of late maturing and mature female prawns in different sizes. The modes are underlined.

a. *Metapenaeus dobsoni*

Season: 1963 to 1964

	Months											
Size group	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
61 - 70 mm	-	-	-	-	-	-	-	-	11	-	1	2
71 - 80 "	-	-	-	-	-	-	-	1	24	4	23	3
81 - 90 "	-	2	3	-	-	4	6	14	22	11	41	20
91 - 100 "	9	5	1	-	-	5	13	52	34	-	43	4
101 - 110 "	23	24	1	-	-	7	10	25	17	-	19	3
111 - 120 "	3	2	-	-	2	11	21	6	3	-	6	-

Season: 1964 to 1965

61 - 70 mm	-	-	-	-	9	-	-	-	-	-	-	-
71 - 80 "	-	-	-	-	43	1	2	1	4	-	1	-
81 - 90 "	6	1	-	-	2	1	19	13	35	5	13	2
91 - 100 "	57	2	-	-	4	4	25	32	82	13	68	7
101 - 110 "	69	1	-	-	15	4	9	13	23	3	40	22
111 - 120 "	1	-	-	-	24	4	34	17	11	2	7	8
121 - 130 "	-	-	-	-	-	1	11	-	1	2	1	-

b. *Metapenaeus affinis*

Season: 1963 to 1964

	Months											
Size group	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
91 - 100 mm	-	-	-	-	-	-	-	4	-	-	-	-
101 - 110 "	-	-	-	-	-	-	3	10	3	2	-	-
111 - 120 "	-	1	-	-	-	5	1	11	2	10	1	2
121 - 130 "	-	2	-	-	-	6	-	3	3	11	1	-
131 - 140 "	-	-	-	-	-	7	2	21	4	7	-	-
141 - 150 "	-	1	-	-	-	1	5	18	3	8	-	-
151 - 160 "	-	-	-	-	-	-	-	2	1	2	2	1
161 - 170 "	-	-	-	-	-	-	-	-	-	-	1	-

Season: 1964 to 1965

91 - 100 mm	-	-	-	-	-	-	-	-	1	-	-	-
101 - 110 "	-	-	-	-	3	-	3	2	9	2	1	1
111 - 120 "	1	-	-	-	6	3	2	4	7	2	3	12
121 - 130 "	-	1	-	-	14	21	3	6	11	7	2	3
131 - 140 "	-	-	-	-	4	14	15	1	9	2	7	1
141 - 150 "	-	-	-	-	2	1	16	9	2	3	7	-
151 - 160 "	1	-	-	-	-	1	4	19	3	1	1	-
161 - 170 "	-	-	-	-	-	1	-	8	2	2	1	-

TABLE II (contd)

c. Penaeus indicus

Season: 1963 to 1964

Size group	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
131 - 140 mm	-	-	-	-	-	-	-	-	-	2	-	-
141 - 150 "	-	-	-	-	2	-	-	-	3	-	-	-
151 - 160 "	-	3	1	1	3	1	-	-	2	1	-	-
161 - 170 "	3	1	6	-	2	1	1	1	3	3	-	-
171 - 180 "	-	-	1	1	4	3	-	2	4	-	-	-
181 - 190 "	-	-	-	-	1	2	1	13	9	2	-	-
191 - 200 "	-	-	-	-	-	1	-	-	-	-	-	-

Season: 1964 to 1965

Size group	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
131 - 140 mm	-	-	-	-	-	-	-	-	1	-	-	-
141 - 150 "	3	-	-	-	3	-	-	-	3	4	3	-
151 - 160 "	5	-	2	-	5	-	-	-	2	3	22	-
161 - 170 "	-	-	3	-	9	1	1	-	-	2	22	-
171 - 180 "	-	-	-	-	10	4	1	-	1	-	3	-
181 - 190 "	-	-	-	-	3	4	1	-	1	-	3	-
191 - 200 "	-	-	-	-	-	3	5	1	-	5	2	-
201 - 210 "	-	-	-	-	-	1	-	-	1	-	-	-

d. Parapenaeopsis stylifera

Season: 1963 to 1964

Size group	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
71 - 80 mm	-	-	-	-	17	23	-	-	3	1	6	6
81 - 90 "	1	-	1	10	29	14	1	-	5	10	8	8
91 - 100 "	5	-	3	12	19	16	3	7	8	9	22	12
101 - 110 "	4	5	1	7	1	7	-	11	10	9	17	14
111 - 120 "	-	3	-	-	-	-	-	3	2	4	5	6
121 - 130 "	-	-	-	-	-	-	-	-	-	2	-	-

Season: 1964 to 1965

Size group	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
61 - 70 mm	-	-	-	-	-	-	-	-	-	-	2	-
71 - 80 "	1	-	-	-	-	1	2	3	-	1	4	9
81 - 90 "	3	1	-	14	17	26	17	6	5	7	14	44
91 - 100 "	5	5	-	17	15	38	47	12	4	4	41	53
101 - 110 "	6	9	-	2	5	4	12	37	13	5	41	38
111 - 120 "	2	-	-	-	-	-	1	7	7	1	12	13
121 - 130 "	-	-	-	-	-	-	-	-	-	-	1	1

E/7

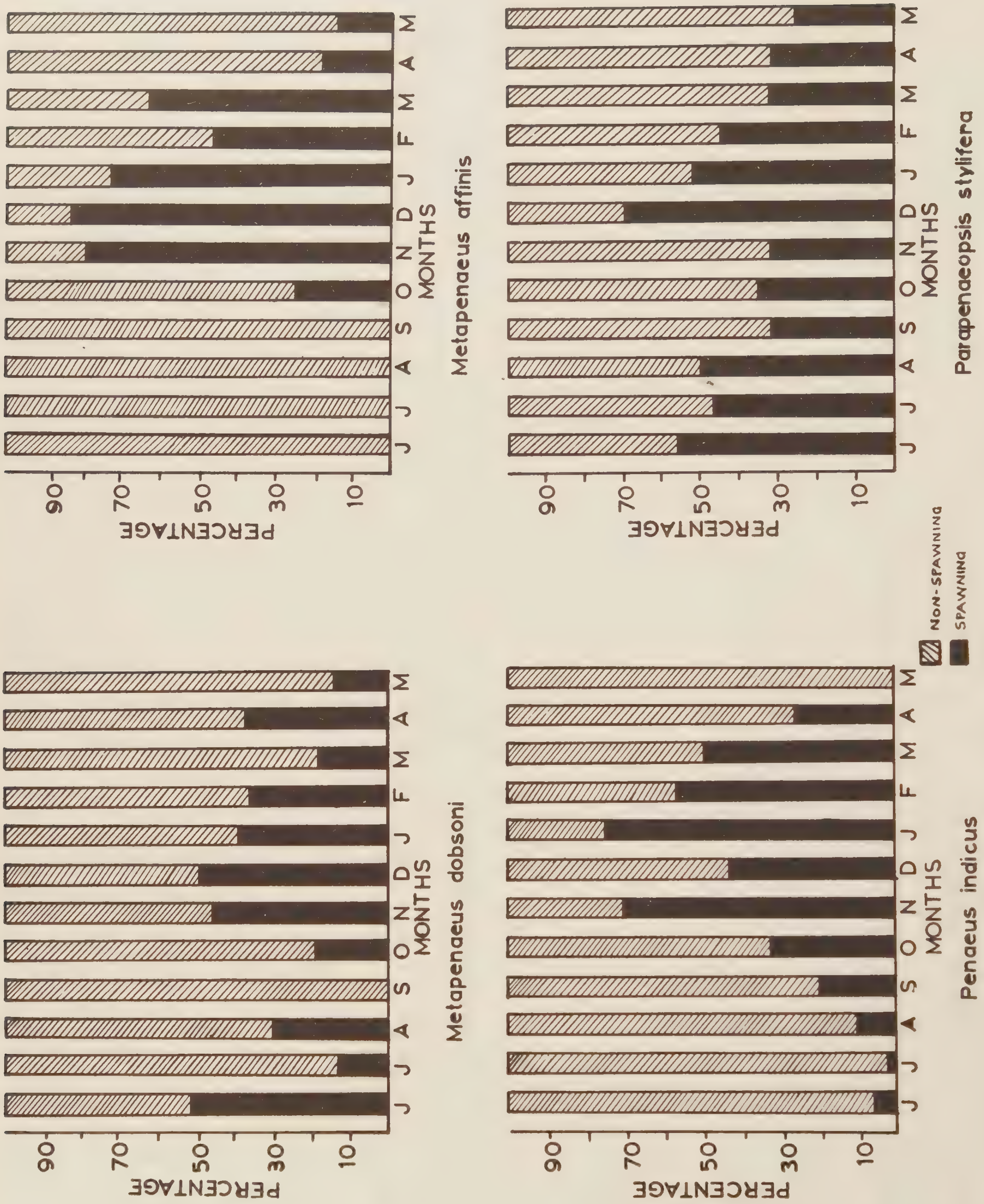

Fig. 7 Monthly percentages of prawns with ovaries in spawning and non-spawning condition.

M. dobsoni: In both years of observation, the 91 to 100 mm length-group provided the greatest number of spawning females between January and April or May, the 101 to 110 mm group were the dominant spawners in June and July, and the 111 to 120 mm group were dominant from October to December (Table II a). The suggested interpretation of these figures is that those females which constituted the 91 to 100 mm length-group in January spawned three times before attaining a length of 111 to 120 mm in December. Such a suggestion is consistent with the growth rate for the species, as determined by Banerji and George (1967).

TABLE III

The length and fecundity relationship and the minimum and maximum number of eggs produced by prawns

Species	Relationship between fecundity and length	Coefficient of correlation (r)	No. of eggs produced Minimum	Maximum
M. dobsoni	Log F = -0.7175+2.8473 Log L	0.8029	34,500 at 70 mm	160,000 at 120 mm
M. affinis	Log F = -0.4306+2.7179 Log L	0.8281	88,000 at 95 mm	363,000 at 160 mm
P. indicus	Log F = -8.1277+6.0808 Log L	0.9716	68,000 at 140 mm	731,000 at 200 mm
P. stylifera	Log F = -1.5746+3.3437 Log L	0.8079	39,500 at 70 mm	236,000 at 120 mm

Although minimum size at first maturity is 64 mm, the least modal size observed for mature prawns is 71 to 80 mm and the next mode is 81 to 90 mm. From this, it could reasonably be deduced that prawns spawn twice before attaining the 91 to 100 mm size. Thus an individual prawn of this species may spawn 5 times during its lifetime.

M. affinis: As the larger mature females of this species are encountered only from October to April, the spawning pattern is not as clear as in other species. However, it is probable (Table II b) that this species also spawns more than once during its growth from 91 to 100 mm to 151 to 160 mm.

P. indicus: In June to August the spawners of this species have a modal length of 161 to 170 mm; in October to November the modal group is 171 to 180 mm, and in January to February it is 181 to 190 mm (Table II c). These figures are consistent with spawning taking place thrice between the size 161 and 190 mm. Since the least size at first maturity is in the 131 to 140 mm group, it may be assumed that these prawns spawn at least twice before entering the 161 to 170 mm group, thus making a total of 5 spawnings during the lifetime of the individual.

P. stylifera: In the case of this species, the 91 to 100 mm modal group of mature prawns is seen in August to September, the 101 to 110 mm group in January to February and again in May to July (Table II d). Again 3 spawnings in a year are suggested. Since the smallest size of the mature prawn obtained is 70 mm, it is quite probable that, as in the case of M. dobsoni, this species also may spawn twice before growing to 91 to 100 mm size, thus making a total of 5 times before reaching the maximum size.

In all these species, it appears that there is a gap of nearly 2 mo between successive spawnings. This probably represents the time taken for the development of the immature ova to the final stage of maturity.

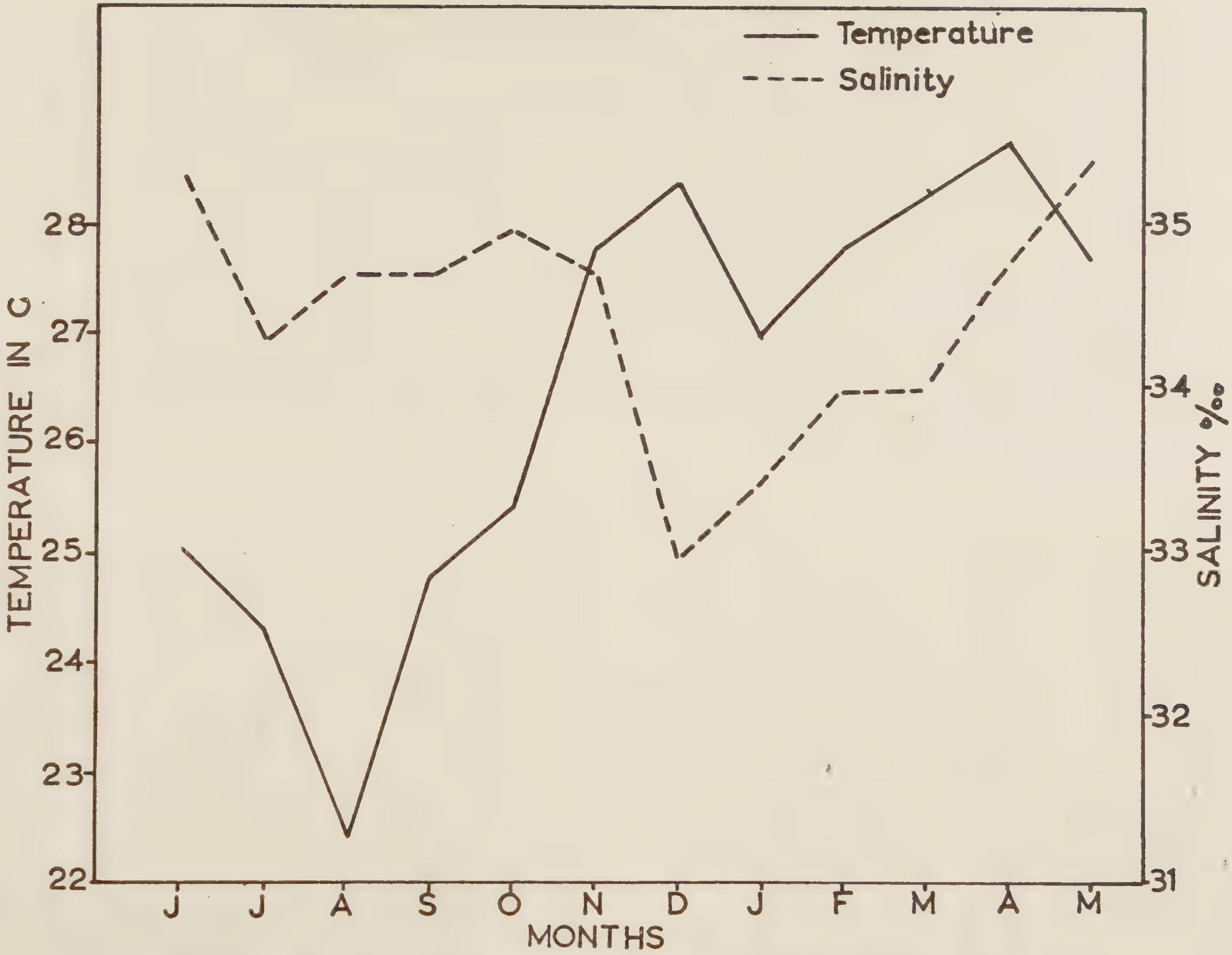

Fig. 8 Seasonal changes in bottom temperature and salinity of the prawn fishing grounds of Cochin during 1963-64.

8 TEMPERATURE, SALINITY AND SPAWNING

Correlation between water temperature and spawning has been reported by Lindner and Anderson (1956), Ingle et al. (1959), Eldred et al. (1961), Cummings (1961) and Idyll, Jones and Dimitriou (1963). It has been shown that intensive spawning activity is generally related to rise in water temperature. The temperature and salinity variations of the bottom waters off Cochin for the year 1963 to 1964 are presented in Fig. 8. During July to September the bottom water temperature of the fishing grounds is less than 25.0°C and few mature females occur during this period. From October onwards the temperature increases, and the highest spawning peaks for most of the species are observed during this period.

There seems to be no clear relation between salinity and spawning. However, it is well known that juveniles of M. dobsoni, M. affinis and P. indicus migrate back to sea from their nursery grounds in the estuaries as they approach adulthood.

9 FECUNDITY

The number of eggs produced by mature females of each species was determined and the relationship between the length of the prawn and fecundity was estimated. It is found that the number of eggs produced varies with the size of the prawn in a logarithmic manner. The length-fecundity relationship for each species and the minimum and maximum number of eggs extruded by the females are given in Table III.

Fecundity of some of the palaemonid prawns has been estimated by Nataraj (1947), Aiyer (1949), Kunju (1956) and Rajyalakshmi (1961). Heldt (1938) found the fecundity of Penaeus kerathurus (as P. trisulcatus) to be between 800,000 and 1,300,000, while Fujinaga (1963) estimated the number of eggs produced in P. japonicus to be 1,200,000 in an individual weighing 25 g. Anderson (1956) reported the fecundity of P. setiferus as between 500,000 and 1,000,000 and Racek (1959) found the number of eggs extruded in Metapenaeus macleayi and M. mastersii to be 350,000 and 200,000 respectively.

10 DISCUSSION

In all the species studied during the present investigation, the distribution of ova in the mature ovaries (Fig. 2(G), 3(E), 4(F) and 5(F)) shows only two groups of ova, representing the immature and the mature stock. Moreover, these two groups are sharply separated from each other in size. As the mature stock of eggs are larger, with transparent peripheral regions, the individuals are either in the spawning condition or very nearly in that condition. Since the mature ova are well differentiated from the immature, spawning is probably restricted to a short and definite period. As the ovaries of spent-recovering specimens contain only small, transparent, yolk-less, immature ova of less than 0.096 mm, it is possible that all the mature ova present in the ovary are liberated at a single spawning act within a short time. Heldt (1938) and Fujinaga (1963) have observed that spawning takes place within 2 to 3 min in other penaeids. The present work suggests that the ova of the immature stock mature in about 2 mo.

The determination of the spawning period and its duration becomes difficult due to the fact that, while breeding is restricted to a short and definite period in the individual prawn, it is rather protracted in the population as a whole. The following explanations may be considered:

(i) There may be different spawning times for younger and older specimens within the parent stock, as has been shown to occur in the decapods Palaemon elegans (as Leander squilla) and Carcinus maenas by Thorson (1946). The data on hand show, however, that in most months prawns of various sizes occur in all stages of maturity.

(ii) The population of each species may be broken into separate units and the spawning in these units is not synchronized. From our present knowledge of the population of these prawns, this does not seem likely.

(iii) Some females may remain in the early ripe condition for a long time preceding actual spawning, in order to tide over the winter and to spawn in the warmer months. This possibility also seems not to be applicable here as the temperature variation of the tropical waters is not significant.

(iv) A prawn may spawn frequently, with only a short duration between successive spawnings.

Prawns of various sizes occur in the samples and it seems likely that individuals of at least 3 of the species are capable of spawning 5 or more times. After each spawning, a group of ova gets separated from the immature stock and attains maturity within about 2 mo. The frequent spawning of individuals of various sizes and the short time between successive spawnings would result in the occurrence of all maturity stages in the fishery, and thereby show a prolonged breeding period in the population as a whole.

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LAS GAMBAS DE INTERES COMERCIAL EN ESPAÑA

por

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Extracto

El autor hace una revisión de la pesca de gambas en las Baleares y en el Atlántico, desde España hasta el Senegal. Existe una serie de especies de gambas que marcan las fluctuaciones de la variación total de crustáceos comestibles. Se enumeran las principales especies y se indican las profundidades de pesca para cada una de ellas.

SHRIMPS OF COMMERCIAL INTEREST IN SPAIN

Abstract

The author reviews briefly the shrimp fishery in the Balearic area and in the Atlantic, from Spain to Senegal. Certain species play an important rôle in the fluctuations of the edible crustacean fishery. The principal commercial species are enumerated and the depths at which these are fished are indicated.

LES CREVETTES D'INTERET COMMERCIAL EN ESPAGNE

Résumé

L'auteur passe en revue les pêches de crevettes aux Baléares et dans l'Atlantique de l'Espagne au Sénégal. Qualques espèces particulierement abondantes jouent un rôle important dans les fluctuations de la pêche totale de crustacés comestibles. Les principales espèces commerciales sont énumérées avec indication de la profondeur à laquelle on les pêche.

1 INTRODUCCION

En la pesca comercial de crustáceos comestibles, un pequeño número de especies aparece en cantidad importante determinando por sí solas las variaciones de las estadísticas totales de crustáceos.

Los datos sobre los cuales hemos basado nuestras observaciones han sido obtenidos entre los años 1940 y 1961. Y es precisamente en este espacio de tiempo cuando la pesca de crustáceos ha adquirido en España su máximo valor económico, en relación con la explotación de nuevos fondos de pesca antes desconocidos o impracticables.

2 ESPECIES DE GAMBAS COMERCIALES

Bajo esta denominación común se incluyen en la región balear todas las especies de Peneidos. Desde el punto de vista comercial solamente presentan interés las siguientes: *Aristeus antennatus* (Risso): gamba rosada; *Aristaeomorpha foliacea* (Risso): gamba roja; *Plesionika edwardsii* (Brandt): carabinero. También presente, pero de muchísimo menor interés, por ser poco abundante: *Parapenaeus longirostris* (Lucas): gamba blanca.

En la región atlántica ocurre todo lo contrario, ya que la especie más interesante económicamente es precisamente *P. longirostris*, denominada vulgarmente gamba. *A. antennatus*, se conoce con el nombre vulgar de gamba moruna; *A. foliacea*, como chorizo; *P. edwardsii* se conoce al igual que en la región balear, como carabinero. Tienen cierto interés económico todas las especies del género *Plesionika*, denominadas vulgarmente camarón.

3 LA PESCA DE GAMBAS EN LA REGION BALEAR

Podemos decir que en España, en general, y en las Islas Baleares en particular, la plataforma continental está supra-explotada, lo que plantea el grave problema de la disminución del rendimiento pesquero en esta zona. La pesca de arrastre, practicada sólo en la plataforma continental llegó a hacerse abusiva al aumentar el número de embarcaciones de pesca y asimismo su capacidad de extracción.

La solución a este problema está en la ampliación del área de pesca, bien hacia otras latitudes (solamente viable a empresas potentes y a barcos de pesca de buen tonelaje) o hacia zonas más profundas, lo que hasta ahora no se había creido interesante por considerarse muy poco productivas las zonas profundas del Mediterráneo. La zona de 150 a 400 m, con fondos de arena fangosa, que hace ya tiempo se explotaba en Cataluña y en Italia, abrió algunas perspectivas y magníficas realidades con la incorporación, relativamente reciente, del área de 400 a 800 m, de fangos arenosos y fangos finos, ricos en crustáceos. Incluso actualmente se han capturados gambas a profundidades de 950 m en el Mar de Alborán.

Nuestro Laboratorio de Palma de Mallorca ha ido acumulando datos sobre estas pesquerías y dado el gran interés económico que representan se encargó de la elaboración de las cartas de pesca.

Todas estas pesquerías sobre el talud desde los 200 a los 1000 m son rentables. Los fondos de 200 a 400 m característicos de *Nephrops norvegicus* (L.) no presentan en las Baleares un interés extraordinario, estando centrada la pesca de arrastre de profundidad en la zona de 400 a 800 m.

Junto con las gambas se captura toda una serie de peces algunos de los cuales de importancia comercial y otros de poco valor que aparecen frecuentemente.

Entre los crustáceos, con menor interés comercial o nulo, además de los citados como base de la pesquería, son característicos de estas zonas: *Plesionika martia* (A. Milne Edwards); *P. heterocarpus* (Costa); *P. acanthonotus* (Smith); *Pasiphaea sivado* (Risso); *Munida rugosa* (Fabricius); *Polycheles typhlops* Heller; *Macropipus tuberculatus* (Roux); *Macropipus depurator* (L.); *Portunus hastatus* (Linné); y *Geryon tridens* Kröyer.

4 LA PESCA DE GAMBAS EN LA REGION DE AFRICA OCCIDENTAL

En Marruecos, la gamba se pesca desde Arcila hasta Casablanca, y aún más al sur, hasta Mazagán.

Los fondos de esta zona, son, en el sector de Arcila, muy arenosos, prácticamente sin fango, pescándose la gamba desde 100 m. Más al sur, entre Rabat y Kenitra, sobre fondos fangosos, se captura desde los 100 y hasta los 200 m. A partir de los 250 m y de noche, se pesca *P. antennatus*.

En los caladeros de Rabat, *Parapenaeus* llega a pescarse a profundidades de solamente 65 m, con la particularidad de que en esta zona los sedimentos fangosos llegan casi hasta la costa. Al igual que en el Mediterráneo y Atlántico español, en estos caladeros se nota claramente la distribución de especies de crustáceos por profundidades.

Pueden considerarse caladeros de gamba, todos los fondos entre 100 y 300 m (para *Parapenaeus*) del Golfo de Cádiz, entre Cabo San Vicente y Tarifa, y en Africa desde Arcila a Cabo Mazagán. Hacia el sur existen pequeños caladeros hasta Cabo Juby donde comienza la zona de captura de langosta, por los arrastreros de altura.

El langostino, abundaba, pero actualmente ha experimentado cierto descenso, en el Mediterráneo, en San Carlos de la Rábida y en el Atlántico en Sanlúcar de Barrameda en la desembocadura del Río Guadalquivir.

En la costa africana hemos estudiado las posibilidades de la ensenada de Biafra y fondos de la Isla de Fernando Poo, obteniendo rendimientos, si no muy importantes para una gran flotilla, sí lo suficientes para la actual flota pesquera de la isla.

5 LAS CARTAS DE PESCA

Son éstas unas cartas levantadas y editadas por el Instituto Español de Oceanografía, orientadas casi exclusivamente a la captura de gambas de profundidad.

Al iniciar el levantamiento de una carta de pesca se apoya en el veril de los 50 m y se extiende hasta los 1000 m. Señalamos el límite de 50 m por considerar que el arrastre no debe actuar por dentro de este veril, y el de los 1000 m, porque, de momento, es el límite de las posibilidades de las gamberas, aunque actualmente se está pescando a menos profundidad.

En las Cartas de Pesca están señaladas las isobatas de 50,100,200,300,400,500,600, 700,800,900, y 1000 m, además de unas cuantas líneas de sonda con los datos completos; no se han incluido todas para evitar un exceso de números.

Para la calidad de fondos, hemos empleado diversos tonos e intensidades de color que contrastan bien con los veriles y sondas que van en negro. En los fondos de cascajo puede haber afloramientos rocosos, en los que el rastreo será difícil o peligroso salvo para pescadores muy experimentados. En las cartas de pesca sólo hemos marcado las rocas que hemos detectado en nuestros sondeos.

En las cartas se señala igualmente el alcance de los faros con arcos en trazo negro fuerte. De las costas se señalan todos aquellos puntos que por ser visibles desde las pesquerías pueden servir de orientación.

Actualmente están levantadas, publicadas o en prensa las cartas de pesca de las Islas Baleares, Cataluña, Levante y la Región Sudmediterránea española. Las consecuencias inmediatas a la publicación de estas cartas de pesca son siempre un incremento en el interés del profesional pesquero hacia estas zonas de pesca profunda que hasta ahora han resultado siempre rentables en gambas.

6 VARIACIONES DE LA PESCA DE GAMBAS DE PROFUNDIDAD DESDE 1940 A 1960

6.1 Región Balear

Hasta 1948, en que se iniciaron las prospecciones, era prácticamente desconocida la gamba de profundidad. Desde 1948, con 16,2 toneladas, la extracción fué aumentando hasta llegar a 1960 con 309 tons, estabilizándose prácticamente a partir de entonces. Estos datos se refieren solamente a las especies A. antennatus y P. edwardsii, contabilizándose únicamente los desembarcos efectuados en la isla, pues hay que tener en cuenta que gran parte de la pesca en estos fondos se desembarca en la península, debido a que la numerosa flotilla que trabaja en los fondos de las Baleares procede de los puertos de Cataluña y Levante.

6.2 Región Atlántica del sur (Golfo de Cádiz)

Bajo la denominación de gamba figura exclusivamente la especie P. longirostris los desembarcos proceden de todo el Golfo de Cádiz y de las costas del Marruecos atlántico.

En 1940 aparece en las estadísticas una extracción de 4298 tons, pasando a 8115 en 1950 y aumentando hasta llegar a 13151 tons en 1960.

Se puede observar que en cada caso el incremento ha sido notable y las grandes diferencias entre una región y otra están también en relación con las flotillas pesqueras respectivas.

* * * * * * *

AUTOMATIC PROCESSING OF WESTERN AUSTRALIAN PRAWN FISHERMEN'S LOG-BOOKS

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Abstract

A system of intensive log-book data collection from Western Australian prawn fishermen is described. To expedite computation and tabulation of this volume containing a considerable amount of data, two computer processing systems have been developed.

The first, designed for the University of Western Australia's PDP-6 computer, summarizes raw data into vessel by area by month groups, giving an immediate overall picture of the industry. Monthly summaries are forwarded to fishermen for their use in estimating the relative efficiencies of their vessels.

The second system, using the Commonwealth Scientific and Industrial Research Organization's CDC 3600 computer, is a system of storage, analysis, handling and retrieval of detailed data. Raw log-book data, landings and programs are stored on magnetic tape and all subsequent processing is carried out in stages, within the computer's high-speed store, magnetic tapes and magnetic drum storage. The results of each processing stage are stored on tape and are readily available for checking. Daily summaries of efforts, adjusted catch of each species, catch per unit of effort (C/UE) and log C/UE are tabulated for each vessel in each area fished. Further programs for this system are being developed.

The system is flexible and could be readily adapted to other research programs where large quantities of data are stored and manipulated.

E/9

TRAITEMENT AUTOMATIQUE DES LIVRES DE BORD DES PECHEURS DE CREVETTES DE L'AUSTRALIE-OCCIDENTALE

Résumé

La communication décrit un système de rassemblement des données des livres de bord des pêcheurs de crevettes de l'Australie Occidentale. Pour accélérer le calcul et la mise en tableaux de la masse considérable de renseignements, on a mis au point deux systèmes de traitement par ordinateur.

Le premier, conçu pour l'ordinateur PDP-6 de l'Université d'Australie-Occidentale, récapitule les données brutes par bateau par zone et par mois. ce qui permet d'avoir immédiatement une idée d'ensemble de l'industrie. Des récapitulations mensuelles sont adressées aux pêcheurs afin qu'ils les utilisent pour évaluer le rendement relatif de leurs bateaux.

Le second est un système de mémorisation, d'analyse, de manipulation et de récupération des données détaillées faisant appel à l'ordinateur CDC 3600 de la Commonwealth Scientific and Industrial Research Organisation. Les données brutes provenant des livres de pêche, ainsi que les détails sur les mises à terre et les programmes sont enregistrés sur bande magnétique, et tout le traitement ultérieur est effectué par étapes par l'ordinateur, au moyen de sa mémoire rapide, de ses bandes magnétiques et de sa mémoire à disques. Les résultats de chaque stade du traitement sont enregistrés sur bande et aisément disponibles aux fins de contrôle. Des récapitulations journalières de l'effort de pêche, des prises ajustées de chaque espèce, des captures par unité d'effort et par livre de pêche sont mises en tableaux pour chaque navire dans chaque zone exploitée. On travaille à l'élaboration de nouveaux programmes dans le cadre de ce système.

Le système, du fait de sa souplesse, pourrait aisément être adapté à d'autres programmes de recherche impliquant l'enregistrement et la manipulation de données très nombreuses.

ELABORACION AUTOMATICA DE LOS DATOS DE LOS REGISTROS DE LOS PESCADORES DE LANGOSTINOS DE AUSTRALIA OCCIDENTAL

Extracto

Se describe un sistema de recogida intensiva de datos de los registros que llevan los pescadores de langostinos de Australia occidental. Para acelerar la computación y tabulación de este considerable volumen de datos, se han establecido dos sistemas de elaboración con calculadoras electrónicas.

El primero, diseñado para la calculadora PDP-6 de la Universidad de Australia Occidental resume los datos brutos por grupos correspondientes a embarcaciones por zona y por mes dando un cuadro completo e inmediato de la industria. Los resúmenes mensuales se envían a los pescadores para que les sirvan para estimar el rendimiento relativo de sus barcos.

El segundo es un sistema de almacenamiento, análisis, manipulación y localización de datos detallados usando la calculadora 3600 CDC de la Organización para la Investigación Científica e Industrial (CSIRO) en el Commonwealth. Los datos brutos del libro-registro, y los detalles de los desembarques y programas se conservan en cintas magnéticas y toda la elaboración ulterior se lleva a cabo por fases en la memoria de acceso rápido de la calculadora, en las cintas magnéticas y en la memoria de las calculadoras de disco. Los resultados de cada fase de elaboración se conservan en cintas que se hallan dispuestas siempre para su comprobación. Se tabulan para cada embarcación en cada zona pescada resúmenes diarios de los esfuerzos, de la captura ajustada de cada especie, de la captura por unidad de esfuerzo (C/UE) y datos de registro C/UE. Se están ideando otros programas para este sistema.

El sistema es flexible y podría ser adaptado fácilmente a otros programas de investigación en los que hay que almacenar y manipular grandes cantidades de datos.

1 INTRODUCTION

Since 1964, detailed information on the operations of prawn trawlers in Shark Bay, Western Australia, has been collected by using log-books issued to skippers. As the volume of these data is considerable (up to 15,000 individual trawl records each year), a system of automatic processing has been devised so that this information can be safely stored, readily manipulated and detailed analyses made. This paper describes the system, the methods of data acquisition, and the methods of producing detailed summaries of these data.

Processing is carried out on two digital computers, the Digital Corporation PDP-6 housed in the Western Australian University and the Control Data Corporation CDC-3600 housed in the Commonwealth Scientific and Industrial Research Organisation Computing Research Section's (CRS) Centre at Canberra, A.C.T. The PDP-6 has approximately 28,000 words of high speed memory storage, using 36 bit words. This installation, at present, is somewhat limited for handling detailed analysis of large volumes of data as its 'hardware' does not include magnetic tape transports or a high speed line printer. Being near the site of data preparation, this machine is used for the initial editing and summarizing of information. The CDC-3600 has 32,768 words of high speed memory storage, using 48 bit words; 8 magnetic tape transports; 1,048,576 words of magnetic drum storage, and a full range of other peripheral equipment. The computer is controlled by the Drum-and-Display (DAD) monitor, which allows computer documents to be recorded on the magnetic drums and held pending execution. This allows series of operations, each having intermediate results, to be returned to the user. CARDIMED and SORT II are amongst the software provided; both are an integral part of the processing system described.

CARDIMED is a procedure devised for the establishment and maintenance of a 'library' of 'data'. This may consist of computer programs or information of any kind capable of being read by the computer. The library consists of versions ('editions'),and is stored on reels of magnetic tape. An edition has the facility of updating itself in response to control cards and information presented to it on input media. It does this by rewriting itself with appropriate amendments. To guard against accidental loss of the library, it is customary to hold the three or four most recent editions.

A card image, or character within a card image, may be altered, or whole images deleted or replaced, by feeding appropriate control cards to the computer. The old edition itself is not altered, but a new reel is prepared incorporating the changes requested. The contents of amended record blocks and a complete inventory of a new edition is output on the line printer.

SORT II accepts a file of records on magnetic tape, arranged in any order, and rearranges these records into a prescribed order, according to sequencing keys contained within each record. The result is identical with that from mechanical sorting.

All routines have been written in FORTRAN IV by the authors.

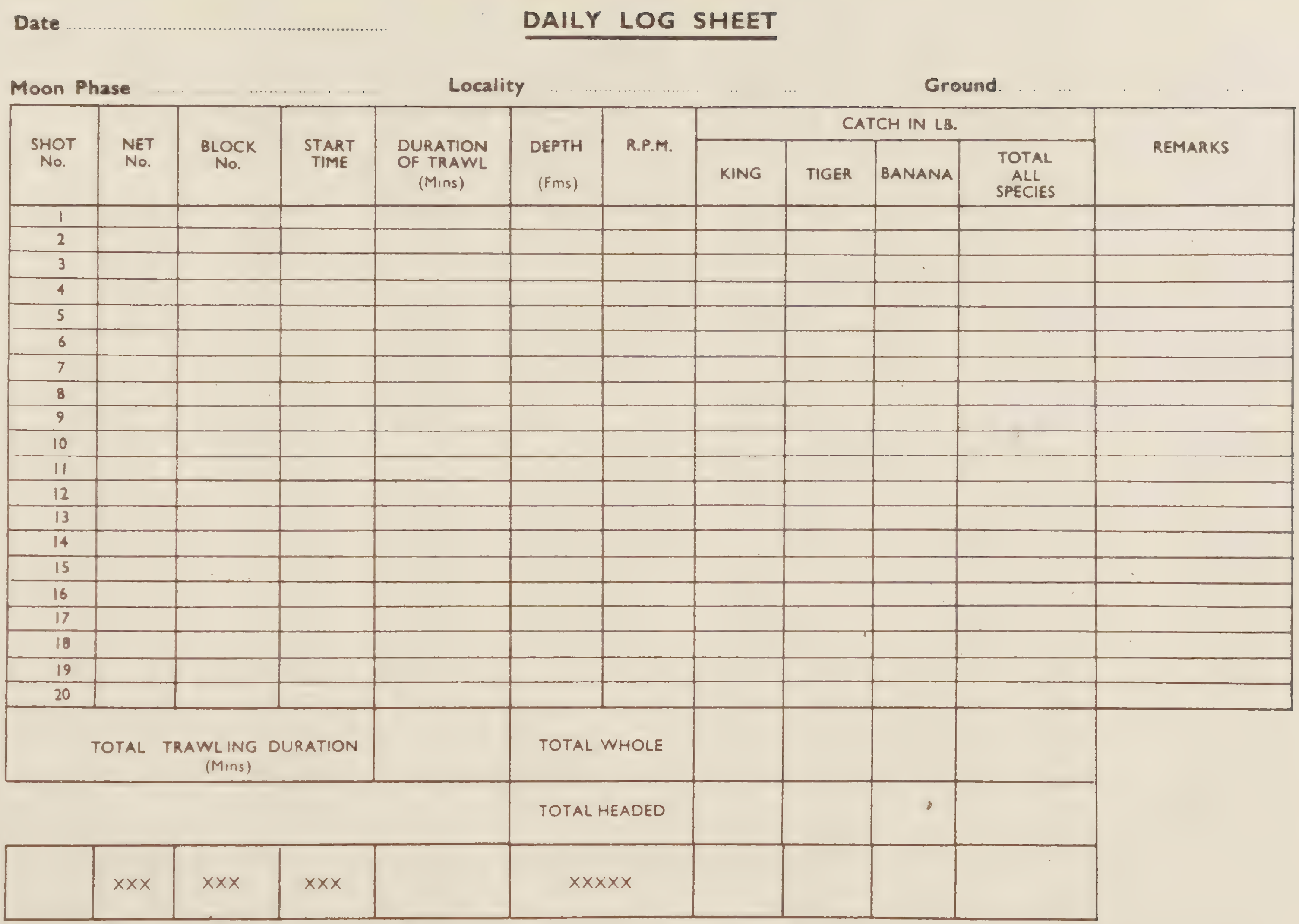
Processing is carried out in three phases:-

(i) data preparation and monthly summaries; (ii) final editing and transfer to the data library; and (iii) production of detailed summaries.

2 PHASE I

2.1 Data collection and preparation

Log-book information is supplied voluntarily by individual skippers who record the circumstances and outcome of each trawl hauled during the course of their operations. The Western Australian Department of Fisheries and Fauna provides log-books specially



Date ....

DAILY LOG SHEET

Moon Phase .... Locality .... Ground ....

SHOT No.	NET No.	BLOCK No.	START TIME	DURATION OF TRAWL (Mins)	DEPTH (Fms)	R.P.M.	CATCH IN LB.				REMARKS
							KING	TIGER	BANANA	TOTAL ALL SPECIES	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
TOTAL TRAWLING DURATION (Mins)					TOTAL WHOLE						
					TOTAL HEADED						
	XXX	XXX	XXX		XXXXX						

Fig. 1 A page of a prawn fishery log-book from Shark Bay.

designed for this purpose. (See Fig. 1 for a typical page from a book). The design of the log is simple; it records adequate research data but is also suitable for fishermen to keep their personal records. The books have duplicate pages impregnated with chemicals, so that the originals remain for the fishermen's use after duplicates have been collected by Departmental personnel. These duplicates are edited to eliminate indistinct or obviously incorrect entries, coded where necessary, and landed catch weights are recorded in the spaces provided. The latter data are obtained independently from the processing sites.

Commonly, fishermen make fishing trips of several days' duration and weigh in their catches on return. At the end of each day's fishing all hauls are summed to give total catches of each species and time fished for that day. These totals are coded for automatic processing by placing 98 in the "Shot No." column. Landed weights are identified by placing 99 in the "Shot No." column.

A card is punched for each completed line, including "98" and "99" lines. After punching, the cards are assembled in the same order as lines on the logs. Fields corresponding to data on the log-sheet are printed on each card to facilitate editing (Fig. 2). Each card is identifiable by its vessel, by skipper number, date, and shot serial number. Vessel and skipper numbers, each between 001 and 499, are assigned arbitrarily. These are kept constant so that a fishing unit can always be identified.

2.2 Elimination of gross errors from the card deck

Invariably, large numbers of incorrect entries occur in card decks punched from the raw log-sheets. Difficulties experienced by card-punch operators in reading these hand-written entries cause most errors. These errors are detected by editing the deck on the PDP-6 using the program SBAYED. This program adds the catches reported for individual shots and compares the sum of reported catches with the processor's records of landed catch. The computer output (Fig. 3) is examined for anomalies and the deck is revised by replacing defective cards manually.

The data deck is again edited using SBAYED to ensure that all errors have been eliminated.

2.3 Compiling of monthly summaries

The data is next run under LOGSUM, a program written to produce monthly summaries of each vessel's operations (Fig. 4). These provide research and administrative personnel of the Fisheries and Fauna Department with up-to-date resumés of the fishery as the season proceeds. Each skipper receives a copy of the summary computed from his log.

Pooled monthly summaries from all vessels fishing in each month can also be obtained if required.

3 PHASE II - FILING NEW INFORMATION ON THE LIBRARY

Before transmission to the CDC 3600 CARDIMED library, the deck is interleaved with appropriate CARDIMED control cards. These divide it into data blocks classified by fishing area, year, and fishing unit number, (i.e., vessel x skipper code). Each block is named by an eight character identifier: the first character is alphabetic (S for Shark Bay, E for Exmouth Gulf, etc.), the second numeric (6 for 1966, etc.), and the remaining 6 are the unit number. The system requires that each block of data does not exceed 1,000 card images; if a natural block exceeds 1,000 images it is manually subdivided into two blocks by adding 500 to the vessel number.

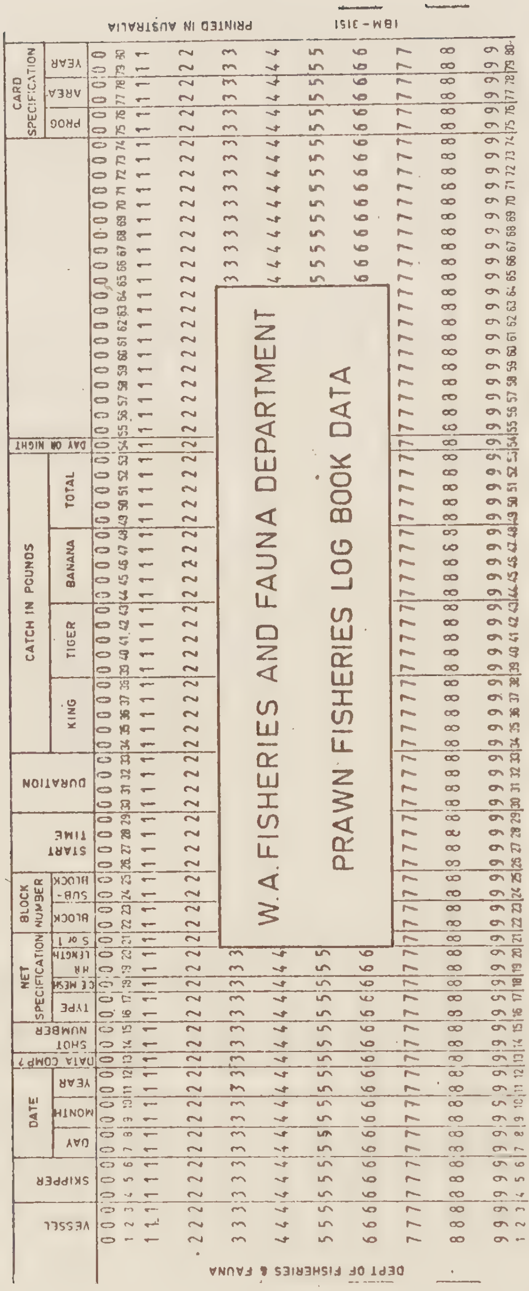


Fig. 2 Card layout for prawn fishery log-book data.

```
        WEST AUST PRAWN FISHERY * LOG BOOK ANALYSIS * BIOLOGIST IC R.J. SLACK-SMITH

TRIP DAY VESS SKIP  D A T E  S.T.CODE  SH   N  E  T  BLOCK  TIME  DUR  KING  TIGER  BANANA  TOTAL  D.C.
  1    1   17   29  18  4 67     3      1   0 78 0   3 0    19 0  120    30    50      0      80    0
  1    1   17   29  18  4 67     3      2   0 78 0   3 0    19 0  120    30   150      0     180    0
  1    1   17   29  18  4 67     3      3   0 78 0   3 0    19 0  120    20    80      0     100    0
  1    1   17   29  18  4 67     3      4   0 78 0   3 0    19 0  120    40   130      0     170    0
  1    1   17   29  18  4 67     3      5   0 78 0   3 0    19 0  120    10   100      0     110    0
  1    1   17   29  18  4 67     3      6   0 78 0   3 0    19 0  120    10    80      0      90    0
  1    1   17   29  18  4 67     3      7   0 78 0   3 0    19 0  120    10   100      0     110    0
  1    1   17   29  18  4 67     3      8   0 78 0   3 0    19 0  120    30    80      0     110    0
  1    1   17   29  18  4 67     3      9   0 78 0   3 0    19 0  120     0    70      0      70    0
  1    1   17   29  18  4 67     3     98   0  0 0   0 0     0 0 1080   180   840      0    1020    0

  1    1     SUM OF     9SHOTS                                     080   180   840      0    1020
         DIFFERENCE SUMS AND RECORDED TOTALS                         0     0     0      0

                             *** NO ADDITION ERRORS ***

                                                CATCH RATE (LB/HR)         10.    47.      0.      57.
                                                LOG(CATCH RATE)        1.0002 1.6691  2.3010

  1    2   17   29  19  4 67     3      1   0 78 0   7 0    19 0  120    20   200      0     220    0
  1    2   17   29  19  4 67     3      2   0 78 0   7 0    19 0  120    20   250      0     270    0
  1    2   17   29  19  4 67     3      3   0 78 0   7 0    19 0  120    10   150      0     160    0
  1    2   17   29  19  4 67     3      4   0 78 0   7 0    19 0  120    25   300      0     325    0
  1    2   17   29  19  4 67     3      5   0 78 0   7 0    19 0  120    50   250      0     300    0
  1    2   17   29  19  4 67     3      6   0 78 0   7 0    19 0  120    10   350      0     360    0
  1    2   17   29  19  4 67     3      7   0 78 0   7 0    19 0  120     0    10      0      10    0
  1    2   17   29  19  4 67     3      8   0 78 0   7 0    19 0  120     0     0      0       0    0
  1    2   17   29  19  4 67     3     98   0  0 0   0 0     0 0  960   135  1510      0    1645    0

  1    2     SUM OF     8SHOTS                                     960   135  1510      0    1645
         DIFFERENCE SUMS AND RECORDED TOTALS                         0     0     0      0

                             *** NO ADDITION ERRORS ***

                                                CATCH RATE (LB/HR)          8.    94.      0.     103.
                                                LOG(CATCH RATE)        0.9265 1.9749  2.3010

  1    3   17   29  19  4 67     3     99   0  0 0   0 0     0 0  0 0   403  1971      0    2374    0

 1       SUM OF RECORDED DAY TOTALS                                2040   315  2350      0    2665

         ABOVE SUM AS PERCENTAGE OF TRIP TOTALS                            78.   119.     0.    112.
```

Fig. 3 A segment of output from the prawn log-book editing program SBAYED.

```
                          DEPARTMENT OF FISHERIES AND FAUNA

                          MONTHLY LOG BOOK SUMMARY - 1966

                                    SHARK BAY


MONTH =  7                        VESSEL =  3                         SKIPPER =  24


BLOCKS FISHED    NO.OF HOURS FISHED             CATCH AND CATCH PER HOUR TRAWLED (LB/HR)


                                                  BANANA            KING              TIGER

                                                LB.   LB/HR      LB.   LB/HR       LB.   LB/HR


     11              30.250                     0.    0.00      877.   28.98      633.   20.91
     22               8.167                     0.    0.00      116.   14.23       94.   11.47
     29              99.917                     0.    0.00     5773.   57.78     2472.   24.74
     36               5.333                     0.    0.00      158.   29.71      135.   25.26
     42              31.833                     0.    0.00     1806.   56.74      211.    6.62
     51              17.083                     0.    0.00      834.   48.85       12.    0.69

           TOTAL MONTHLY CATCH RATE                 0.00          47.02             15.76

                                               TOTALS

DAYS =  23       HOURS =  192.583      TRAWLS =  177      BANANA =  0      KING =  9565      TIGER =  3555

MEAN TRAWLS PER DAY =  7.696        MEAN HOURS PER DAY =  8.373

ALL CATCHES SHOWN HAVE BEEN ADJUSTED TO AGREE WITH LANDINGS
```

Fig.4 Typical monthly summary computed from Shark Bay prawn log-books. These summaries are produced by the program LOGSUM.

The deck, together with control cards, is then submitted to the computer.

After the deck has been copied on to the library, the new contents are edited using SBAYEDIT (the CDC 3600 version of SBAYED) to detect any errors which may have passed unnoticed at the first editing or have been introduced in manipulating the cards or copying them on to the library.

4 PHASE III - THE WESPRAWN SYSTEM

4.1 Outline of the WESPRAWN System

WESPRAWN has been designed so that it will accept widely-varying amounts of data without modifications to the routines. Furthermore, because of the flexibility of CARDIMED, amendments can be made easily to any data on the library, including high-refinod summaries. This capability, together with the fact that WESPRAWN itself is carried out in a number of distinct phases, ensures that an unnoticed deficiency in the data, detected at any processing phase, can be remedied without going through either the whole set of data or the whole processing procedure. Data may be processed piecemeal or as a whole for any given area. WESPRAWN is capable of easy modification to accept data of any sort which is substantially in the same format as described above.

Routines stored on the library can be invoked by presenting appropriate calling (control) cards to the computer. Similarly, data of any order of refinement stored on the library may be transcribed to temporary storage media, such as 'scratch' magnetic tape or in the form of 'documents' to magnetic drums. The routines can then be commanded to process the data by presenting the necessary control cards. Thus, once the routines and data are stored on the library, it is possible to commence processing by presenting small decks of control cards to the computer.

4.2 Haul adjustment and separation

Using the routine CADJREC, hauls are adjusted so that the sum of catches taken in each haul agree with the total landed catches of each trip. In the same operation new lines of information, one for each haul, are written in data blocks on magnetic tape. These blocks are interspersed by end-of-file marks. These lines are in the form of card images; the first part is the original haul data, the second is a series of adjusted catches, and the final part an area code (e.g. T for Shark Bay) with the month of the year (e.g. T6). Simultaneously, control cards are punched on-line by the computer. These are used to add the new blocks of adjusted data on the library. A segment of this output is shown in Fig. 5.

4.3 Sorting blocks of adjusted data

In this step, blocks of adjusted data are copied from the library on magnetic tape, re-arranged into day x fishing x area order with SORT II, and are then output on another magnetic tape. Hauls are sorted so that those belonging to the first day come first, followed by all the second day hauls, etc. Within each day-group the hauls are sorted in order of area.

4.4 Computing effort, catch and catch per unit of effort

The sorted file described above is now processed by SBAYCOMP, which summarizes the data within each day x block subclass. When it detects a change in date or block a new subclass summary is commenced. Each haul is recognized by its unit number. SBAYCOMP must be provided with a list of fishing units appropriate to the particular run; at present the number of these units is limited to 50. The sequence of data and blocks within dates need not follow any special pattern, thus making this routine quite flexible with respect to the structure of the data. In addition to the day x

```
                                      *RECORD,40,T5040060,NL,'ADJUSTED WAP BLOCK NUMBER  7
04006018 66510100048034  1815  15   35   00   00   35   35.0   0.0   0.0      T5
04006018 66510200048034  1840  20   20   00   00   20   20.0   0.0   0.0      T5
04006018 66510300048034  1910  15   20   00   00   20   20.0   0.0   0.0      T5
04006018 66510400048034  1935  15   35   00   00   35   35.0   0.0   0.0      T5
04006018 66510500048034  2000  15   25   00   00   25   25.0   0.0   0.0      T5
04006018 66510600048034  2030  15   35   00   00   35   35.0   0.0   0.0      T5
04006018 66510700048034  2055  15   35   05   00   40   35.0   5.0   0.0      T5
04006018 66510800048034  2120  15   30   00   00   30   30.0   0.0   0.0      T5
```

Fig. 5 A segment output from the trawl adjusting program ADJREC .

```
                          WA PRAWN FISHERIES * LOG BOOK ANALYSIS * SHARK BAY  1964

                                         VESSEL X DAY X BLOCK SUMMARY

                                  MONTH   4          DAY   1          BLOCK  22

FISHING UNIT NO. OF SHOTS  TOTAL DURATION         KING                           TIGER
                                              CATCH(LB) CR(LB/HR) LOGCR CATCH(LB) CR(LB/HR) LOGCR

   1  3          0              0.00

   2  4         17              3.67            665       181.3   2.2584    357         97.2   1.9878

   3  5          3              1.25             59        47.2   1.6739     19         15.2   1.1818

   6  9          0              0.00

   6 10          0              0.00

  30 51          0              0.00
```

Fig. 6 A summary or prawn fishing operations in a particular area (block) for a particular day computed by the WESPRAWN system.

block summaries, tables combining all data for blocks fished during each day are compiled. A specimen of the output is given in Fig. 6.

4.5 Proposed extensions to WESPRAWN

Proposed extensions and refinements to this processing system include:

(1) Provisions for addition of day x block summaries to the CARDIMED library.

(2) A routine (T4HR), to convert all "start times" recorded on the log sheets to 24 hour time, has been written. This routine will allow time recorded on log sheets to be punched directly, thus eliminating a large amount of coding.

(3) Maps of the fishing areas overlaid with selected catch-rate data will be produced on the graph-plotter.

(4) Improved data-scanning facilities and more comprehensive diagnostic output will be written into existing routines, so that data deficiences will be more effictively eliminated.

5 DISCUSSION

The Western Australian prawn fishery extends several hundred miles north of Shark Bay and further expansion is now occurring. Its detailed growth is difficult for existing research staff to monitor manually. Intensive log book promotion has resulted in a high proportion of fishermen accepting log books from the Fisheries and Fauna Department, primarily to keep their own records. Most skippers willingly post in duplicates from areas not visited by research staff. The data obtained can now be stored and summarized using the processing systems described above, thus providing adequate up-to-date figures for administrative purposes and storing detailed data in a form readily available for later analysis.

Copies of the routines, and further details of these systems may be obtained from either author.

* * * * * * *

FRECUENCIA DE CAMARON POSTLARVAL (PENAEUS FABRICIUS 1798) RELACIONADA CON LA TEMPERATURA Y SALINIDAD EN LA COSTA DE CIUDAD MADERO, TAMAULIPAS, MEXICO

por

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Extracto

Se da a conocer el comportamiento de los camarones peneidos postlarvales con respecto a la temperatura y salinidad, así como la temporada de su mayor abundancia. La salinidad no mostró ninguna influencia en la presencia de las postlarvas. La temperatura tiene, aparentemente, influencia mayor sobre esta presencia. La mayor abundancia de peneidos se observó en los meses comprendidos entre noviembre y marzo y la escase fue más notoria de junio a octubre.

CORRELATION OF FREQUENCY OF POSTLARVAL SHRIMP (PENAEUS FABRICIUS 1798) TO TEMPERATURE AND SALINITY OF THE COAST NEA CIUDAD MADERO, TAMAULIPAS, MEXICO

Abstract

The behaviour of post-larval penaeid shrimp is correlated to temperature and salinity, and periods of relative abundance are recorded. Differences in salinity appeared to have no effect on the presence of post-larval forms; temperature on the other hand has a significant effect. The greatest abundance of penaeid shrimp was observed between November and March, while their scarcity was most evident from June to October.

E/10

FREQUENCE DES STÁDES POST-LARVAIRES DE CREVETTES (PENAEUS FABRICIUS 1798) EN FONCTION DE LA TEMPERATURE ET DE LA SALINITE DES EAUX COTIERES DE CIUDAD MADERO (ETAT DE TAMAULIPAS) MEXIQUE

Résumé

L'auteur étudie le comportement des stades post-larvaires des crevettes Pénéidés en fonction de la température et de la salinité de l'eau, ainsi que l'époque d'abondance maximale. La salinité n'exerce aucune incidence sur la présence des stades post-larvaires, alors que la température joue apparemment un rôle important. C'est entre novembre et mars que les Pénéidés sont le plus abondants. Leur nombre est particulièrement faible entre juin et octobre.

1 INTRODUCCION

Es conocida de todos la importancia económica de los crustáceos como camarón, langosta, jaiba y gambas entre otros. Debido a que en México los camarones ocupan el primer lugar, se efectuó este trabajo con el propósito de conocer el comportamiento de sus estadios postlarvales en relación con algunos cambios ecológicos a través del año, observar la temporada de mayor y menor abundancia, y más adelante realizar un estudio de las especies de interés comercial que habitan nuestra área de estudio.

Los muestreos se iniciaron en el mes de diciembre de 1965 concluyendo en el mes de noviembre de 1966, con un total de 51 colectas, las cuales fueron semanales, todas por la mañana, entre las 09:00 y 11:00 horas siendo siempre el lugar de colecta el conocido por el nombre de "La Casita" que se localiza a cinco kilómetros al norte de la desembocadura del Río Pánuco en el Municipio de Ciudad Madero, Tamaulipas. Se escogió este lugar después de muestrear una zona de siete kilómetros a intervalos de uno, durante los dos primeros meses, sin encontrar variaciones en el material colectado y por la accesibilidad del lugar durante la alta marea y época de vientos del norte (Fig. 1).

2 MATERIAL Y METODO DE ESTUDIO

La salinidad se determinó con densímetro para densidades de 1.010 a 1.030 calibrado a 60°F. La temperatura se tomó con un termométro de 0° a 50°C, excepto los meses de mayo y junio en que se usó un termohalinoconductímetro (Cuadro I).

Las colectas se efectuaron con red de arrastre manual formada por tres partes: cuerpo, cono y portacolector, pues su forma semeja mucho la de un embudo. La técnica seguida es la misma empleada por Baxter (1962).

Una vez obtenida la muestra se preservó con agua de mar y formol al 5 por ciento.

En laboratorio las muestras se cuantificaron e identificaron de acuerdo a las claves de Anderson y Lindner (1943), Dobkin (1961), Cook (1966) y Baxter y Fisher (comunicación personal). Todo el material analizado quedó identificado dentro del género Penaeus Fabricius de la familia Penaeidae.

3 RELACION DE POSTLARVAS CON LA SALINIDAD

Durante los últimos años, la mayoría de los investigadores consideran la influencia de la salinidad como un factor secundario en la supervivencia del camarón, entre ellos Lindner y Anderson (1956). Broad (1962) escribe que no se ha comprobado el efecto de la salinidad sobre el crecimiento y distribución de estos crustáceos. Sin embargo, otros autores como Pearse y Gunter (1957) escriben que muchos animales requieren áreas de baja salinidad para su nutrición y crecimiento. La distribución y abundancia de la jaiba (Callinectes) y del camarón (Penaeus) en las costas del Golfo de México y del Atlántico dependen de la presencia de áreas estuarinas y agregan que el camarón desova en aguas oceánicas. Durante sus primeras fases parece necesitar de altas salinidades, pero en las fases juveniles se localiza en aguas de baja salinidad (lagunas, bahías, esteros) regresando una vez que ha alcanzado su estado adulto a mar abierto. Zein-Eldin (1963) concluye que: a) la supervivencia fue alta en salinidades comprendidas entre 2, 5, 10, 25 y 40°/oo; b) la salinidad no limita el crecimiento de los camarones postlarvales.

En otro experimento llevado a cabo por Zein-Eldin y Aldrich (1963) para analizar la tolerancia del camarón a la temperatura y salinidad, los datos de supervivencia demostraron que estos peneidos resistieron amplia variación de salinidad y que el crecimiento continuó dentro de todas las condiciones, concluyendo que el crecimiento y supervivencia están más relacionados con otros factores que con la salinidad.

E/10

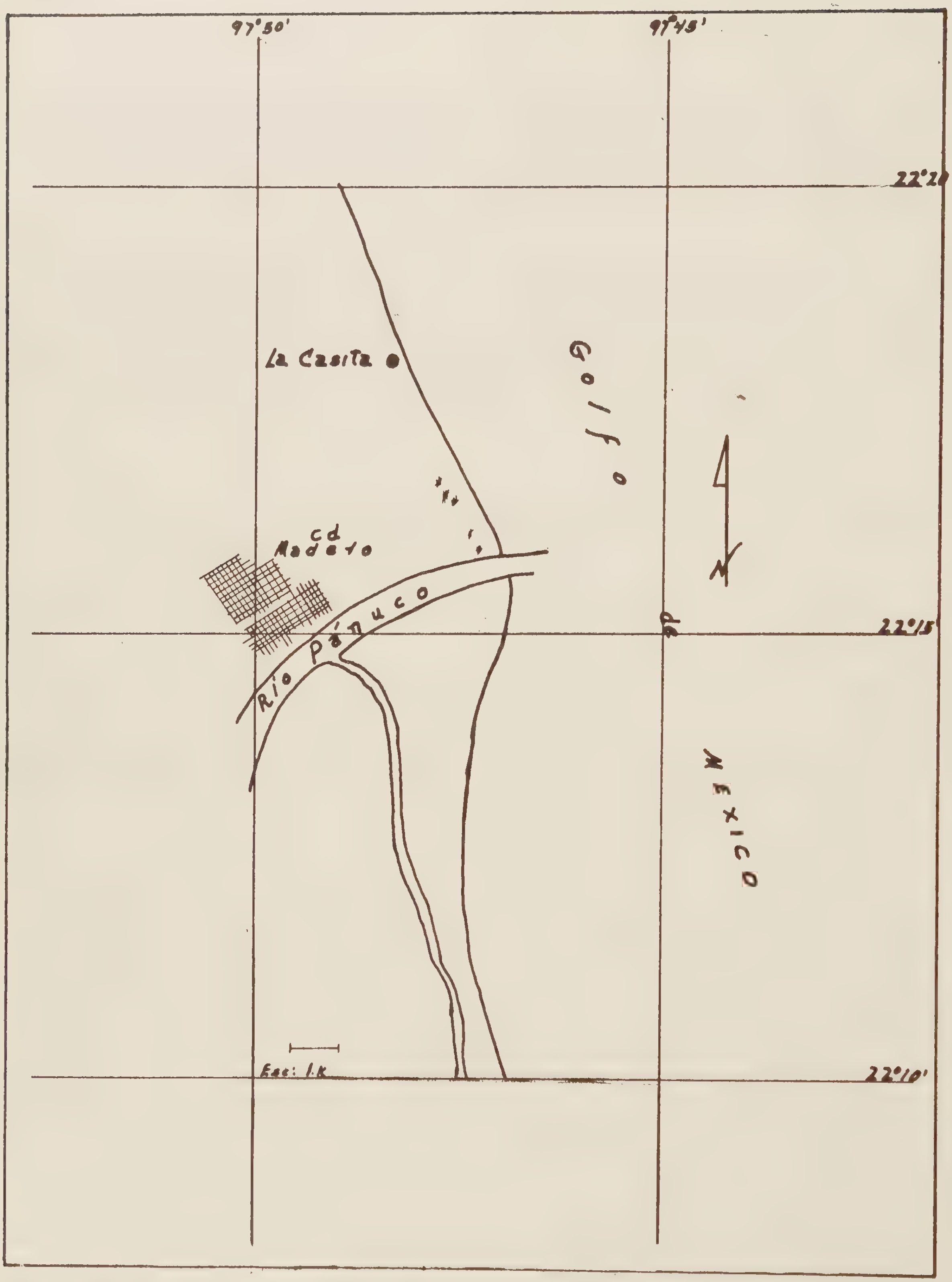

Fig. 1 Zona de colectas: La Casita, 5 km al norte de la desembocadura del Río Pánuco.

CUADRO I

Temperatura, Salinidad y Abundancia de Postlarvas Obtenidas en La Casita, Ciudad Madero, Tamaulipas

Fecha	No. de Colecta	Hora	Temp. °C	Salinidad °/oo	No. Post-larvas
6.12.65	100	09:30	20,0	37,00	18
11.12.65	101	10:00	23,0	40,10	5
18.12.65	102	10:00	24,0	37,50	0
27.12.65	103	08:20	20,0	38,00	239
5.1.66	104	11:00	19,0	37,50	316
8.1.66	105	10:50	20,0	37,50	0
15.1.66	106	09:50	19,0	37,00	141
22.1.66	107	10:10	14,0	37,30	0
28.1.66	108	09:10	14,0	36,80	137
14.2.66	109	09:00	17,0	36,30	130
19.2.66	110	09:50	17,0	35,50	27
26.2.66	111	10:15	16,0	35,00	2
5.3.66	112	10:15	16,0	——	810
12.3.66	113	10:00	19,0	35,30	13
19.3.66	114	09:35	21,0	35,50	3
26.3.66	115	10:00	18,0	34,70	12
2.4.66	116	10:55	20,0	35,10	0
11.4.66	117	09:10	22,5	35,50	2
16.4.66	118	11:50	24,0	31,90	1
23.4.66	119	09:45	25,6	32,66	2
30.4.66	120	10:05	26,0	35,90	2
7.5.66	121	10:30	25,6	30,90*	36
16.5.66	122	12:05	26,9	31,54*	0
21.5.66	123	10:20	26,6	31,68*	0
30.5.66	124	11:15	27,2	32,44*	0
4.6.66	125	10:45	28,1	32,94*	0
11.6.66	126	10:10	25,9	32,96*	0
20.6.66	127	08:50	25,1	30,20*	0
29.6.66	128	09:40	28,4	30,53*	2
2.7.66	129	10:45	29,7	31,64*	0
9.7.66	130	11:15	27,0	35,00	0
16.7.66	131	10:10	27,5	37,60	0
22.7.66	132	10:10	27,5	37,60	5
30.7.66	133	10:25	23,5	35,00	1
6.8.66	134	10:45	24,5	36,80	0
13.8.66	135	10:20	23,5	35,40	7
20.8.66	136	10:40	24,0	38,40	1
27.8.66	137	10:00	30,0	35,50	0
3.9.66	138	09:55	26,5	31,90	1
10.9.66	139	10:20	27,5	35,40	0
17.9.66	140	09:45	28,0	36,60	1
24.9.66	141	10:10	28,5	35,30	0
1.10.66	142	10:00	26,5	36,60	4
8.10.66	143	09:30	28,5	35,90	4
15.10.66	144	10:00	28,0	35,30	7
22.10.66	145	11:00	28,0	35,10	0
29.10.66	146	11:00	24,0	36,00	0
5.11.66	147	10:05	24,5	35,80	0
14.11.66	148	10:00	24,5	35,30	0
22.11.66	149	10:20	26,0	35,60	2
29.11.66	150	10:10	21,0	37,90	71

* Datos obtenidos directamente del Termohalinoconductímetro (THC)

CUADRO II

Promedios Mensuales de Temperatura, Salinidad y Postlarvas

Meses	Temp. °C	Salinidad °/oo	No. de Postlarvas
Diciembre	21,75	38,15	65,5
Enero	17,20	37,22	118,8
Febrero	16,66	35,60	53,0
Marzo	18,50	35,16	209,5
Abril	23,62	34,21	1,4
Mayo	26,57	31,64	9,0
Junio	26,87	31,65	0,5
Julio	27,04	35,36	1,2
Agosto	25,50	36,52	2,0
Septiembre	27,62	34,80	0,5
Octubre	27,00	35,78	3,0
Noviembre	24,00	36,15	18,2

De acuerdo con los resultados que presentamos (Cuadro II, Figs. 2 y 4[1/]), encontramos que la mayor frecuencia de postlarvas se presenta en los meses de noviembre a marzo y la más baja entre junio y octubre. En los primeros la salinidad fluctúa entre 35 y 38o/oo siendo en los segundos de 31 a 36°/oo. Analizando cada captura mensual respecto a la salinidad presente, notamos que no existe aparentemente ninguna relación entre la salinidad y la presencia de camarones postlarvales.

4 RELACION DE POSTLARVAS CON LA TEMPERATURA

La temperatura es uno de los factores que más influye en las especies. Hutchins (1947) puntualiza que la distribución de las especies está en relación con las estaciones de verano e invierno. Idyll (1950) trabajando en el área de Dry Tortugas, E.U.A. y Hildebrand (1955) en el área de Campeche, México, indican que Penaeus duorarum es común en las aguas templadas o tropicales. Sin embargo en aguas de Carolina del Norte E.U.A., Williams (1955) reporta esta especie en capturas realizadas durante los meses de invierno a temperaturas de 4°C aunque se les encontró enterrados bajo el substrato; este mismo autor observa un incremento de captura en aguas con temperaturas de 15°C.

1/ La Fig. 4 ha sido arreglada convencionalmente. Observese la progresión de postlarvas y factores en relación con los meses.

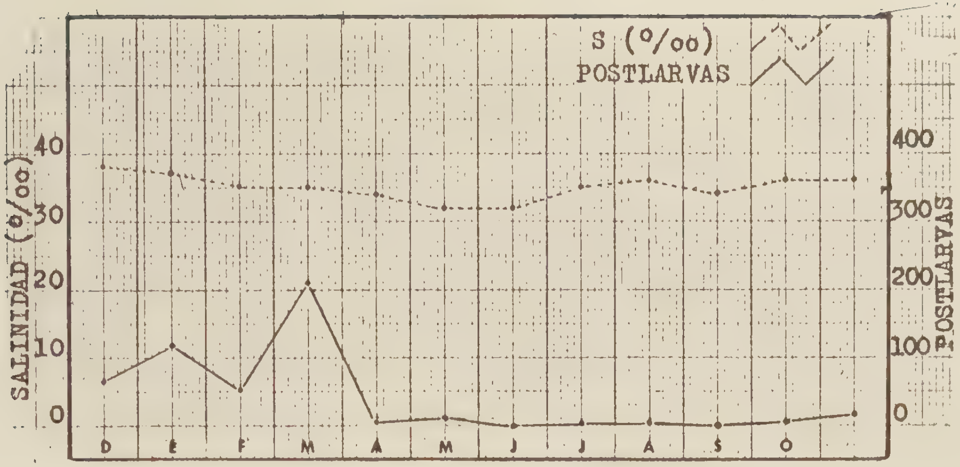

Fig. 2 Interrelación postlarvas/salinidad.

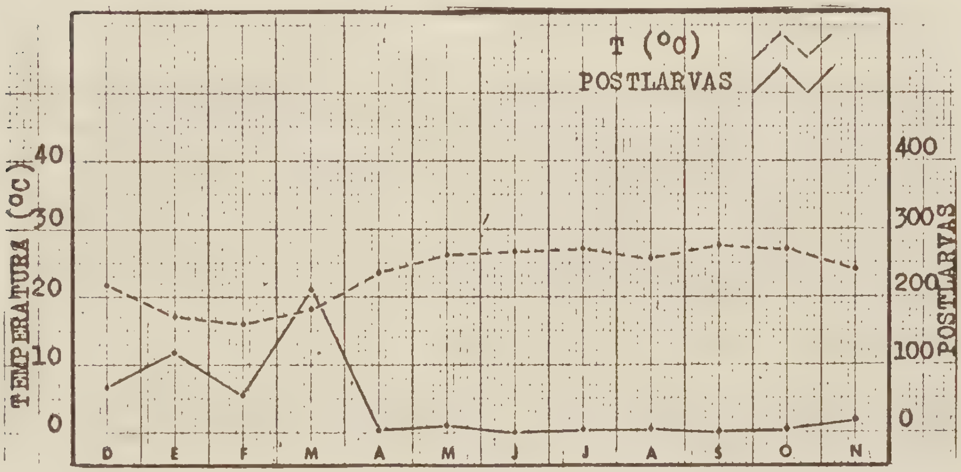

Fig. 3 Interrelación postlarvas/temperatura.

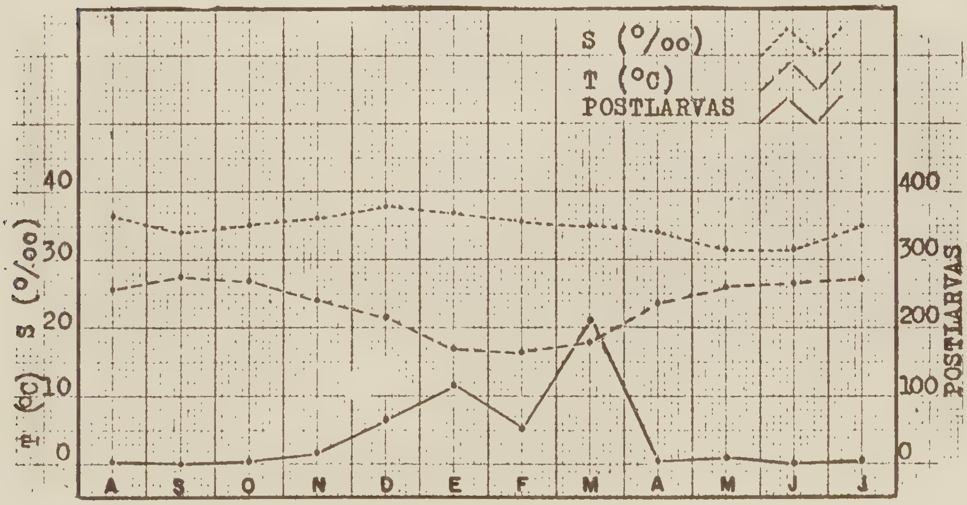

Fig. 4 Interrelación postlarvas/salinidad y temperatura.

Eldred et al. (1961) basándose en sus estudios realizados con camarón (Penaeus duorarum Burkenroad) no establecen una temperatura mínima para la supervivencia de esta especie, pero proponen la de 12°C, desconociendo la máxima temperatura a que puede sobrevivir mencionando únicamente colectas de camarón en el área de la Bahía de Tampa, E.U.A., a temperaturas de 35,5°C durante el mes de agosto. Williams (1955) da la máxima temperatura de 35°C en Carolina del Norte, E.U.A. encontrándolo de nuevo enterrado en el substrato, deduciendo que se protege de esta manera de los extremos de temperatura en verano e invierno. Zein-Eldin y Aldrich (1963) en su estudio de la tolerancia del camarón a la temperatura y salinidad encontraron un 100 por ciento de supervivencia con temperaturas entre los 20 y 32°C y salinidades de 5 a 37°/oo y un 100 por ciento de mortalidad con temperaturas superiores a los 35°C o inferiores a 15°C y salinidades de 5°/oo para abajo. En cuanto al crecimiento se observaron los siguientes datos:

Temperatura 32°C y salinidad de 25°/oo; crecimiento excelente
Temperatura 25°C y salinidad de 15°/oo; crecimiento bueno
Temperatura 18°C y salinidad de 5°/oo; crecimiento regular
Temperatura 12°C y salinidad de 2°/oo; ningún crecimiento

Concluyeron que el crecimiento aparentemente está más relacionado con la temperatura que con la salinidad.

Nosotros, por nuestra parte, y de acuerdo con los promedios mensuales obtenidos (Cuadro II y Figs. 3 y 4) observamos una franca incidencia de postlarvas en los meses cuya temperatura oscila entre los 16.6° y 21.7°C, viéndose a la vez la ausencia de ésta en temperatúras superiores a los 24°C que en este caso llegaron hasta los 27,5°C. En algunos meses se presenta una marcada diferencia en la cantidad de postlarvas; entre los meses de diciembre a marzo se registran las temperaturas más bajas y a la vez las mayores capturas y de junio a octubre las temperaturas son superiores a los 26°C y la presencia de postlarvas es mínima o nula.

5 DISCUSION Y CONCLUSIONES

Tomando muy en cuenta la temperada de reproducción de estos peneidos, es lógico encontrar períodos de abundancia y escasez; así mismo debemos considerar la importancia que tienen las regiones cercanas a las desembocaduras de ríos, lagunas y esteros, pues el arrastre de material orgánico por las corrientes que desembocan al mar juegan un papel primordial en la presencia de estas especies.

En nuestro estudio se presentaron las mayores capturas de ejemplares postlarvales con las temperaturas promedio más bajas observadas: 16 y 21°C. La escasez fue notoria en aquellos meses en que las temperaturas fueron por arriba de los 24° hasta 27,5°C (Cuadro II y Figs. 3 y 4). El período de mayor abundancia fue desde el mes de noviembre hasta el mes de marzo, notándose un claro descenso en el número de postlarvas en los meses más calurosos del año. Por el contrario, con respecto a la salinidad, (Cuadro II y Figs. 2 y 4) con excepción de los meses de diciembre y enero en que se anotaron las más altas en promedio (37 y 38°/oo) y mayo y junio con las más bajas (31°/oo), el resto del año se mantiene entre los 34 y 35°/oo. Concluyendo, se puede decir que no hay una marcada influencia entre la frecuencia de postlarvas y la salinidad, no sucediendo lo mismo con la temperatura, la cual, aparentemente, está más relacionada con la presencia de las postlarvas.

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ESTUDIO DE LA BIOLOGIA DEL CAMARON CAFE
Penaeus californiensis HOLMES

por

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Extracto

Este trabajo ha sido enfocado principalmente al conocimiento del ciclo gonadal del camarón café, *Penaeus californiensis* Holmes dentro de la zona del noroeste del Pacífico mexicano, donde representa aproximadamente un 80 por ciento de las capturas. Se compara con otro peneido, *P. setiferus* (Linnaeus). Se incluye un análisis superficial de la producción total de las especies de *Penaeus* que se explotan comercialmente en la zona.

STUDY OF THE BIOLOGY OF THE BROWN SHRIMP
Penaeus californiensis HOLMES

Abstract

The paper deals mainly with the gonad cycle of the brown shrimp, *Penaeus californiensis* Holmes in the northwest Pacific zone of Mexico, where this species constitutes about 80 percent of the catches. A comparison is made with another penaeid shrimp, *P. setiferus* (Linnaeus). A provisional analysis is given of the total production of commercially exploited shrimp of the genus *Penaeus* in this zone.

CONTRIBUTION A L'ETUDE DE LA BIOLOGIE DE *Penaeus californiensis* HOLMES

Résumé

Le présent document traite essentiellement de l'étude du cycle sexuel de *Penaeus californiensis* Holmes dans la partie nord-ouest du Pacifique mexicain, où cette crevette représente environ 80 pour cent des prises. Cette espèce est comparée avec un autre Pénéidé, *P. setiferus* Linnaeus. L'auteur procède ensuite à une analyse sommaire de la production totale des espèces de *Penaeus* qui sont commercialement exploitées dans la zone en question.

1 INTRODUCCION

El camarón café *Penaeus californiensis* Holmes, 1900, es uno de los recursos marinos que mayores beneficios aporta a la economía pesquera nacional, pues soporta importantes pesquerías a lo largo del litoral del Pacífico, siendo su captura más intensa en la productiva zona del noroeste de México.

El género *Penaeus* ha recibido especial atención por parte de instituciones y de biólogos pesqueros de todos los países en que se explota comercialmente, como ocurre, por ejemplo, en los E.U.A. donde este recurso representa una de las pesquerías más importantes de la zona del Golfo de México.

El camarón café es de gran importancia económica para México, puesto que es una de las especies explotadas en la región noroeste durante casi todo el año. Según Carranza (1963), la industria camaronera produjo en 1961 por concepto de exportación, 518 millones de pesos, cifra que en 1965, según el Anuario Estadístico del Comercio Exterior de los Estados Unidos Mexicanos, fue de $551.450.000,00[1] por 27.049 toneladas de camarón en diferentes grados de industrialización. La importancia económica que este recurso tiene para México se destaca en el Cuadro I.

CUADRO I

Comparativo de los principales recursos marinos explotados en el Estado de Sinaloa en el año 1962

Nombre del recurso explotado	Por ciento del volumen total	Por ciento del valor total
Camarón, incluyendo las 4 especies explotadas en el noroeste	74,4	88,6
Sierra	3,6	0,7
Lisa	2,8	1,3
Corvina	1,0	0,5
Pescado	2,3	1,1
Cazón	0,9	0
Ostión	2,7	0,6
Carne mariscos	0,9	1,1
Rana	2,5	2,5
Otros	4,7	2,7
Harina	4,2	0,8

Fuente de información: Atlas Pesquero Nacional (Gutiérrez, 1965)

Los datos del Cuadro I se refieren exclusivamente a la producción del Estado de Sinaloa, porque constituye el área total en donde pescan las embarcaciones de la flota de Mazatlán de las que se tomaron las muestras de camarón café que sirvieron para la realización de este trabajo. En el Estado de Sonora, la producción total de camarón representa el 87,1 por ciento de los 5 recursos marinos más importantes (Gutiérrez, 1965).

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[1] Un peso mexicano = E.U.A. $0,08

Según datos proporcionados por las congeladoras de la zona y elaborados en el Instituto Nacional de Investigaciones Biológico-Pesqueras, a partir de 1960 el camarón café representa el 80 por ciento de las capturas comerciales.

Sobre la base de los datos proporcionados por la Oficina de Estadística de la Dirección General de Pesca e Industrias Conexas, de la Secretaría de Industria y Comercio, se presenta a continuación un breve análisis de las actividades de la flota de Mazatlán, referente a la explotación de las cuatro especies de Penaeus de esta zona. Los datos corresponden a siete temporadas, comprendidas de 1958 a 1965. Los datos de peso del camarón en kilogramos se refieren a camarones descabezados; en la preparación de estos datos y de los gráficos correspondientes se tomaron en cuenta solamente las embarcaciones que realizaron más de cinco viajes en una sola temporada.

En la Fig. 1 se aprecia la evolución de la pesquería mencionada. En la Fig. 2 puede verse que la época de mayor producción fue la comprendida entre los años 1959 y 1962, pero en la temporada de 1962 a 1963, a pesar del incremento en el número de embarcaciones, o tal vez a causa de éste, declina la producción, lo que indica que las poblaciones de camarones no soportaron el efecto de la pesca realizada ese año. Esto es más evidente en la Fig. 3. Debe aclararse que en la elaboración de estos datos no se tomó en cuenta la flota de Salina Cruz, que también opera en la zona de Mazatlán.

De acuerdo con los datos del Registro Nacional de Embarcaciones de la Dirección General de Pesca e Industrias Conexas para el año de 1965, las cooperativas que integran esa flota son 19 y están distribuidas desde Yavaros, Sonora, hasta el Puerto de Mazatlán, Sinaloa.

Al iniciarse las operaciones anuales a finales de verano al levantarse la veda, los movimientos de la flota se realizan fundamentalmente frente a la desembocadura del Río San Lorenzo, Sinaloa, para seguir después hacia el norte. Luego se dirigen hacia el sur, hasta Punta Mita, Nayarit, y sólo excepcionalmente siguen más al sur, frente a litorales nayaritas todavía. Durante la época de veda que en Sinaloa comprende del 15 de julio al 15 de septiembre, algunas embarcaciones salen a pescar al Golfo de Tehuantepec, Oaxaca, donde no existe veda.

1.1 Objetivos

El conocimiento de la evolución cíclica gonadal de P. californiensis, en comparación con otros estudios de este tipo, ha sido el enfoque principal de este trabajo, en virtud de la importancia que tiene el reconocer con relativa seguridad algunos pasos de su ciclo biológico, como base para su mejor extracción y aprovechamiento.

1.2 Antecedentes

King (1948) estudió fundamentalmente la anatomía y la histología general de las gónadas en ambos sexos de P. setiferus, y como tarea principal se planteó determinar si los caracteres estructurales de las gónadas pueden servir como índice para determinar la edad y la longevidad, y si proporcionan información sobre la frecuencia de desoves de un solo individuo en una sola estación de apareamiento. De acuerdo con los resultados que obtuvo, una hembra desova más de una vez en una sola estación de apareamiento.

Cárdenas (1951) proporciona datos acerca de los artes de pesca empleados para capturar las especies de camarón que se explotan comercialmente en esta región; aborda problemas de filogenia, de taxonomía y de distribución geográfica y establece el ciclo biológico de 3 especies.

El trabajo de Núñez (1954), en la zona pesquera de la Bahía de Guaymas, Sonora, comprende principalmente aspectos bioestadísticos.

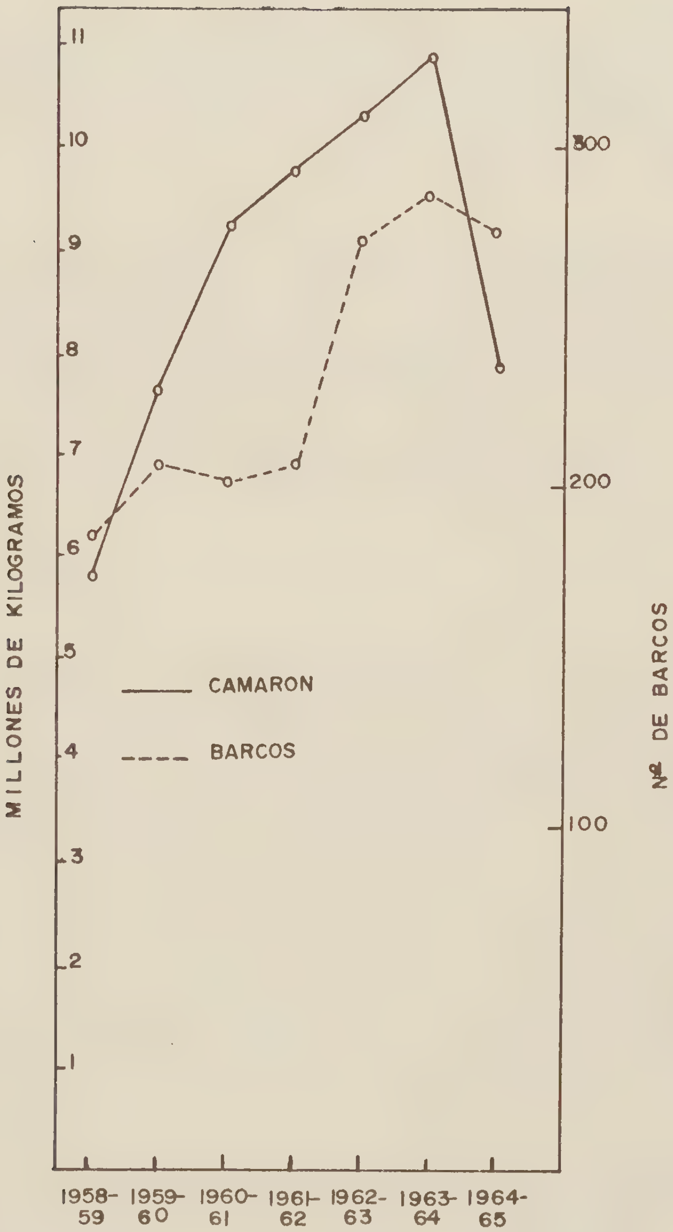


Fig. 1 Capturas anuales de la flota de Mazatlán, Sinaloa.

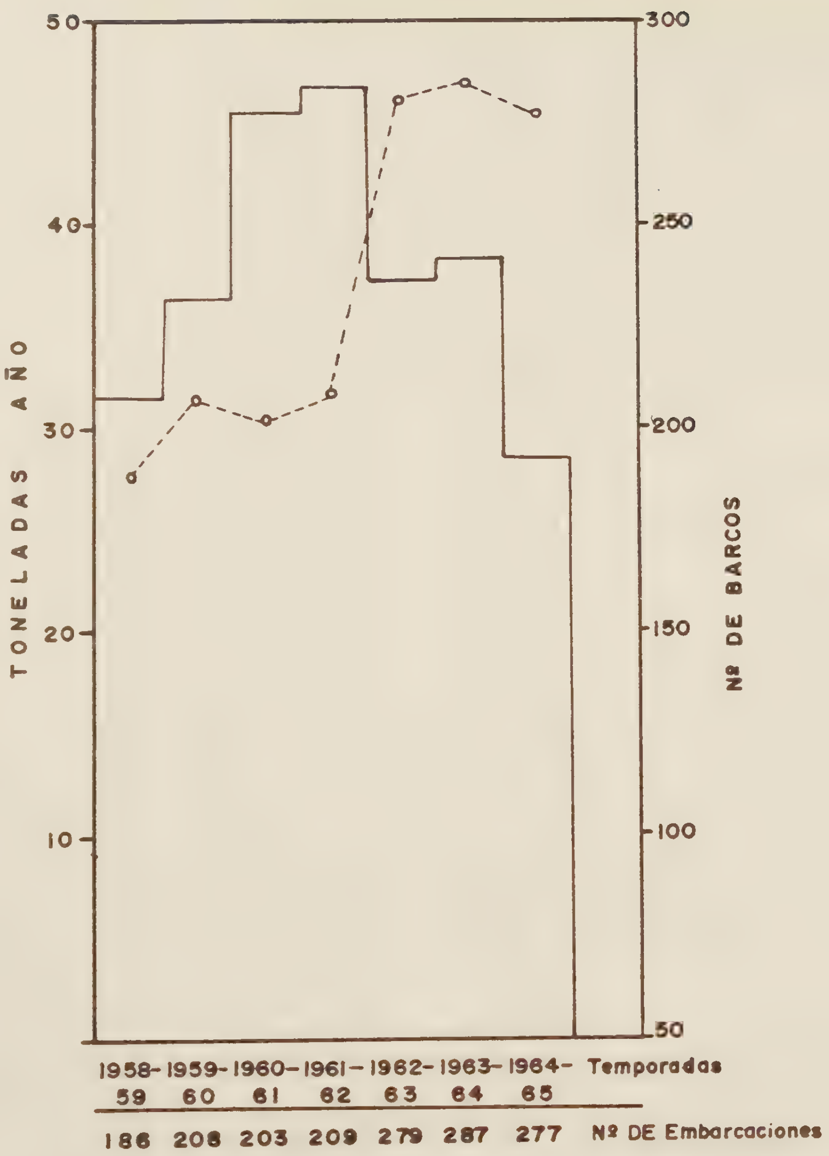


Fig. 2 Promedio anual de captura por embarcación.

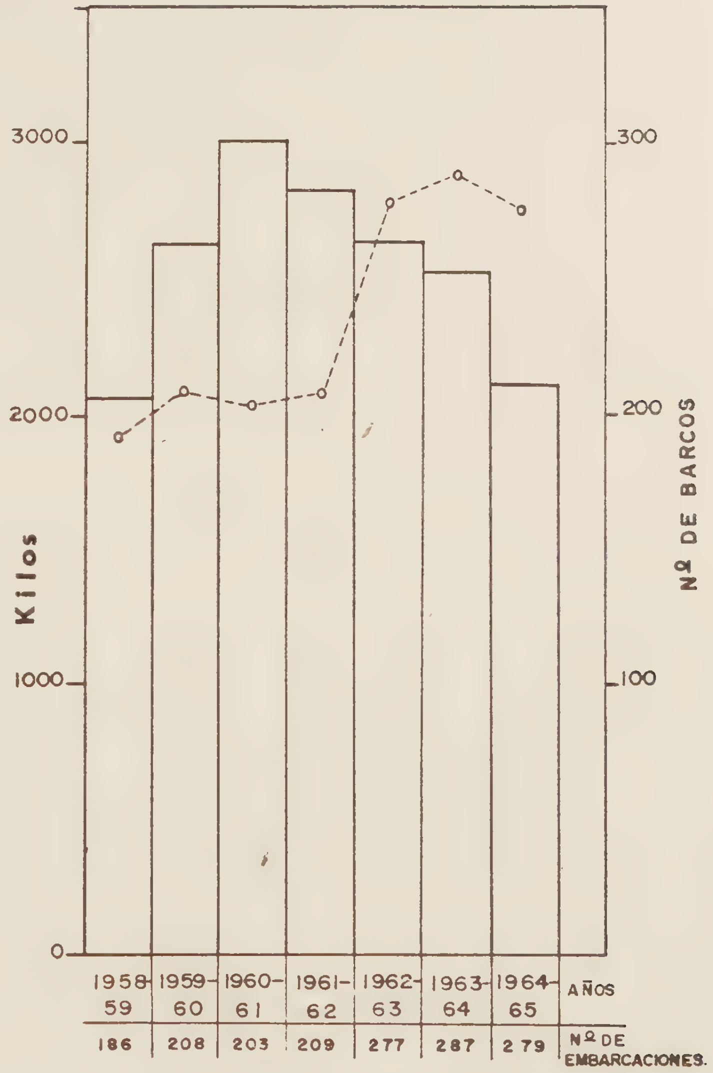


Fig. 3 Captura por unidad de esfuerzo.

Chapa (1956) señaló la posibilidad de reconocer macroscópicamente la madurez sexual de varios peneidos de explotación comercial en la parte noroeste del Pacífico mexicano. Este investigador se basa en la variación de color que presenta el ovario a través del ciclo gonadal; toma también en cuenta la coloración externa, así como la diferencia de tamaño entre el macho y la hembra, cuando han alcanzado su madurez sexual.

1.3 Area de estudio

El área de estudio se localiza en la zona en que se realizan los movimientos de la flota de Mazatlán. En términos generales, esta flota opera desde los límites de los Estados de Sonora y Sinaloa en el norte, hasta Punta Mita, Nayarit, en el sur. El mapa (Fig. 4) muestra el área aproximada de captura de la flota de Mazatlán (Chapa, 1956). Se señalan las localidades de muestreo, sobre cuya base se formó el ciclo gonadal.

En el Estado de Sinaloa, con 648 kilómetros de litoral, se pescan estos peneidos abundantemente. Esta zona tiene un sistema hidrográfico formado por 118 ríos, agrupados en las 12 cuencas más importantes del Estado. En números redondos el caudal de escurrimiento de estos ríos es de 4.400 millones de metros cúbicos anuales (promedio de los años comprendidos entre 1955-1964), según datos obtenidos en el Boletín Hidrológico No. 26, Región Noroeste, de la Secretaría de Recursos Hidráulicos 1965.

En general, los ríos en Sinaloa desembocan directamente en el mar; forman muchas veces las lagunas costeras, marismas o esteros. El clima que predomina en el litoral sinaloense es tipo semi-árido caliente, con temporada de lluvias en los períodos de verano e invierno.

2 MATERIAL Y METODOS DE CAPTURA

Las muestras de camarón café que sirvieron para la elaboración de este trabajo fueron tomadas por el personal de la Estación de Biología Pesquera de Mazatlán, a bordo de embarcaciones de la flota camaronera de ese puerto. El material se envió preservado para su estudio al laboratorio central del Instituto Nacional de Investigaciones Biológico-Pesqueras. La toma de muestras se realizó mensualmente, y cada una de ellas, tomada al azar, estuvo formada por 50 ejemplares aproximadamente. Durante el desarrollo del trabajo se midieron 1.014 ejemplares, de uno y otro sexos y se hicieron preparaciones histológicas del aparato reproductor de 5 machos y 5 hembras de cada muestra.

Los ejemplares de muestra se lavaron con agua dulce, en algunos casos, antes de ser fijados en formol al 10 por ciento. Más tarde, siguiendo las indicaciones de Boschi (comunicación personal), este fijador se desechó y en su lugar se empleó el líquido de Bouin-Hollande, para proseguir después con la técnica modificada de Petterfi. Una vez fijados los ejemplares, se prepararon en cámara húmeda y se enviaron por avión al laboratorio central del Instituto Nacional de Investigaciones Biológico-Pesqueras.

Al llegar al laboratorio de histología se midieron los ejemplares según el método recomendado por Pérez, Acosta y Alemany (1961). Sobre esta base se tomaron longitudes totales, se determinó el sexo y se les numeró progresivamente, empezando con la captura correspondiente al mes de mayo de 1965. El número correspondiente a

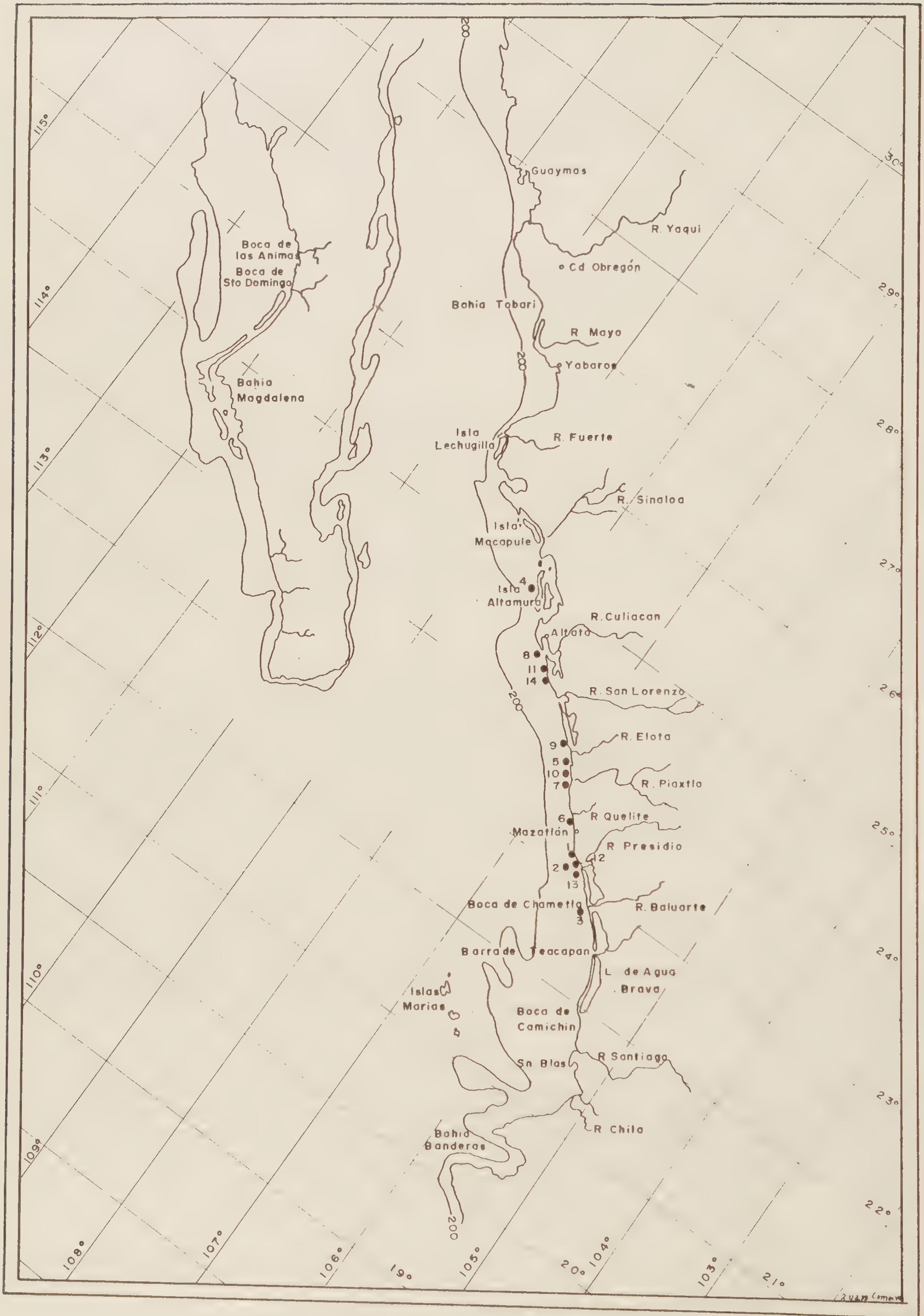


Fig. 4 Localidades de captura (tomado de Chapa, 1956).

cada ejemplar se marcó con tinta china en un rectángulo de papel blanco colocado en la región branquial, aprovechando el caparazón mismo como sostén del papel marcado. Después de fijados los ejemplares y de haberlos medido y marcado, se hizo la disección en un promedio de 5 hembras y 5 machos elegidos al azar, en cada captura. Se disecaron, en cada caso, los ovarios completos y los testículos con su canal deferente y ampolla terminal.

En el caso de las hembras, y sobre todo cuando se trató de ejemplares maduros, se cortó la glándula en tres o cuatro secciones transversales, a las que se les puso el número del ejemplar seguido de una letra a, m, ó p, para indicar que la posición relativa de la sección en el individuo era anterior, medio o posterior, respectivamente. Esto fue necesario porque el ovario, que se encuentra en la parte dorsal, se extiende desde la región anterior del cefalotórax hasta la parte terminal del abdomen. Los ejemplares no disecados se guardaron en alcohol de 70°.

Se incluyeron las secciones de gónadas en parafina de 49-51° de punto de fusión y se tiñeron con Hematoxilina-Eosina. Se montaron en resina sintética y se observaron al microscopio compuesto usando luz artificial. Se procuró usar las preparaciones más representativas de cada mes. Después se ensayaron varios tipos de películas para trabajar con el fotomicroscopio y con el microscopio de contraste de fases, usando un aditamento especial para montar una cámara fotográfica. De esta serie de fotografías se seleccionó la mejor de cada mes y que fuera también la más representativa del diferente grado de desarrollo del proceso de madurez gonadal. Los óvulos y ovocitos se midieron con escalas previamente fotografiadas y reproducidas al mismo tamaño que la serie de fotografías obtenidas. Se introdujeron las siguientes variantes a la técnica sugerida por Boschi: a) se utilizó el fijador Bouin-Hollande que fue sugerido por Irma López G. en 1965, que está comprobado es un buen fijador para insectos de caparazón duro semejante al del camarón café; b) se utilizó parafina del más bajo punto de fusión existente en el mercado; c) por sugerencia de Alma Flores M., se utilizó carbonato de litio para lavar las secciones de gónadas fijadas en solución Bouin-Hollande.

3 DISTRIBUCION GEOGRAFICA

Biogeográficamente puede considerarse que este peneido pertenece a la provincia panámica, que, en términos generales, abarca desde Isla Cedros, Baja California, hasta Payta, Perú (Keen, 1958). Sin embargo, de acuerdo con esta misma autora, será necesario hacer una subdivisión para esta zona, en virtud de que la distribución de las especies en la región mencionada no es uniforme.

La zona en donde la explotación del camarón café es más intensa se localiza en la costa noroeste del Pacífico mexicano, región considerada por algunos autores como subprovincia californiana. Entre otras características de esta subprovincia, se tienen los aportes que recibe en la porción norte, con los que llegan sedimentos provenientes del Río Colorado. Por otro lado, son pocas las especies tropicales que se extienden hasta ella. Para el Mar de Cortés en especial, Parker (1964), reconoce dos regiones diferentes, una al norte de Mazatlán y otra al sur.

3.1 Areas de captura

Los datos que se dan aquí proceden principalmente de informes proporcionados por investigadores y colectores que han tomado muestras en esta zona de capturas de tipo comercial o de capturas de cruceros de investigación oceanográfica; estos muestreos marcan aproximadamente el área de distribución geográfica de la especie que es objeto de este estudio.

La captura del camarón café se efectúa principalmente en zonas costeras que, por encontrarse sobre plataforma continental y por su profundidad, pueden considerarse bentónicas neríticas. La distribución batimétrica aproximada para P. californiensis es de entre 10 y 55 brazas (18 a 100 m) según datos obtenidos durante los muestreos realizados por el personal de la Estación de Biología Pesquera de Mazatlán (1965-66).

Los tipos más comunes de sustrato en que se le encuentra, son fondos limoarcillosos o fangosos. Según Rioja (1962) los fondos ocupados por los peneidos del Golfo de México son aquellos que están un poco más alejados de las playas arenosas, en fondos de fango entre 10 y 15 brazas de profundidad.

Es importante la influencia que ejercen algunos factores ecológicos tales como la salinidad, temperatura, iluminación y nutrientes, y no sólo determinan la abundancia, sino también el comportamiento de estas comunidades que, aunque permanecen durante todo el año en aguas profundas y sólo en contadas ocasiones se han colectado escasos ejemplares en bahías y esteros, no por esto dejan de considerarse poblaciones costeras, puesto que habitan, como se ha dicho antes, sobre la plataforma continental, zona en la cual juegan un papel decisivo los factores arriba citados. En términos generales, las zonas de captura del camarón café en México se extienden desde Baja California hasta Chiapas.

De acuerdo con Chapa (1956), en los litorales occidentales del territorio sur de Baja California se captura el camarón café desde la Boca de San Gregorio hasta el Cabo San Lázaro, a profundidades de 12 a 25 brazas (22 a 46 m). De Boca de los Inocentes hasta el Arroyo de la Candelaria, a una profundidad aproximada de 20 brazas (37 m).

En el Mar de Cortés (Golfo de California), en la desembocadura del Río Colorado, se pesca a profundidades de 15 a 20 brazas (28 a 37 m).

Según datos proporcionados por Victor Díaz Garcés (comunicación personal), sobre las capturas con redes de arrastre realizadas y estudiadas por Alejandro Villamar Calderón (comunicación personal) durante el crucero INIBPYO-6602, a bordo del buque motor YOLANDA se obtuvieron ejemplares de P. californiensis en las siguientes zonas de aguas protegidas: Bahía Concepción y Bahía de la Paz (Baja California) entre 10 y 11 brazas y Bahía Agua Dulce y Estero de Tastiota (Sonora) entre 7 y 25 brazas de profundidad. En otro crucero (GP-4-6601) Sergio Antonio Guzman del Próo capturó un pequeño número de ejemplares en la Bahía Magdalena y al norte de ésta.

En Sonora se le explota en Desemboque, en la desembocadura del Río Asunción. Es muy abundante en la Barra de Yavaros y en la Bahía de Guaymas, entre 8 y 25 brazas (15 a 46 m). Se le encuentra en casi todo el litoral al sur de Guaymas hasta el estero de Agiabampo, entre 10 y 15 brazas (18 a 27 m) (Chapa, 1956).

Es esta la especie dominante en las capturas comerciales de alta mar del Estado de Sinaloa desde noviembre hasta enero, a profundidades de 18 a 30 brazas (33 a 55 m); después desaparece hasta el mes de julio en que vuelve a aumentar (Lizárraga, 1964).

En el mapa (Fig. 4) se señalan con círculos negros las localidades del litoral sinaloense en las que el personal de la Estación de Biología Pesquera de Mazatlán ha capturado ejemplares de P. californiensis. Dichas localidades son: Boca del Río Presidio (1); frente a Barrón (2); Chametla, frente al Cerro Cabeza de Caballo (3); Isla Altamura (4); entre Piaxtla y San Miguel (5); frente al Faro Crestón (6); Boca del Río Piaxtla (7); El Tambor (8); La Cruz de Piaxtla (9); frente a la Isla Venados (10); Los Cocos (11); Boca Barrón (12); frente a Teacapán (13); Palma Sola (14).

En el Estado de Nayarit se encuentran poblaciones pequeñas y alejadas de la costa las cuales ya no se explotan comercialmente, y sólo en Salina Cruz, Oaxaca, vuelve a haber poblaciones dignas de explotación comercial.

4 APARATO REPRODUCTOR DE Penaeus californiensis

4.1 Aparato reproductor femenino

Según King (1948), el aparato reproductor en las hembras de P. setiferus consta de un par de ovarios, que presentan en estado fresco una forma más o menos triangular. Conforme se desarrollan, los ovarios aumentan de diámetro y se van uniendo, de modo que en las hembras grávidas dan la impresión de estar perfectamente unidos. La glándula presenta un par de oviductos que son finos tubos que se comunican a los lóbulos laterales con los orificios o poros genitales (Fig. 5c) localizados en la base de las coxas del tercer par de pereiópodos. Eldred (1958) compara estas aberturas con estructuras semejantes a puertas falsas, que se abren sólo en el momento del desove y que se vuelven a cerrar cuando se ha realizado esta función. Según esta misma investigadora, la región anterior del ovario de P. duorarum consta de dos lóbulos anteriores, localizados entre el estómago, siguen luego ocho pares de lóbulos también situados en la región anterior del cefalotórax y colocados dorsalmente al hepatopáncreas. Estos lóbulos se comunican con los lóbulos abdominales, que llegan hasta la parte posterior del abdomen. En los ejemplares de P. californiensis que se estudiaron para este trabajo, se encontró una separación de los dos ovarios a la altura del último segmento abdominal, sitio donde el intestino toma una posición central y dorsal (Fig. 7).

El télico (Fig. 5b) que forma parte del aparato reproductor, es una estructura externa quitinizada, colocada ventralmente entre el cuarto y quinto par de pereiópodos. Internamente está modificado presentando una estructura que recibe a los espermatóforos adheridos por el macho. Aparentemente esta cavidad funciona como una espermateca, y se denomina receptáculo seminal (Eldred, 1958). Esta modificación externa, que comprende a los somites XII, XIII y XIV, constituye un carácter para determinar el sexo en hembras no menores de 26 mm, según experiencias efectuadas con P. duorarum (Eldred, 1958).

De acuerdo con King (1948), el ovario presenta tres diferentes tipos de tejidos, a saber: a) una delgada capa externa de epitelio pavimentoso; b) una capa media de tejido conectivo, y c) una capa de epitelio germinal. El ovario se encuentra atravesado longitudinalmente por septos de tejido conectivo, y en corte transversal se advierten pequeños senos sanguíneos. Los diferentes tipos celulares que se describen en este trabajo son esencialmente:

Ovocitos: células del epitelio germinal, de forma poliédrica, con escasos nucléolos; se localizan generalmente en sitios determinados de la gónada, en forma de columna. Miden entre 27 μ y 50 μ.

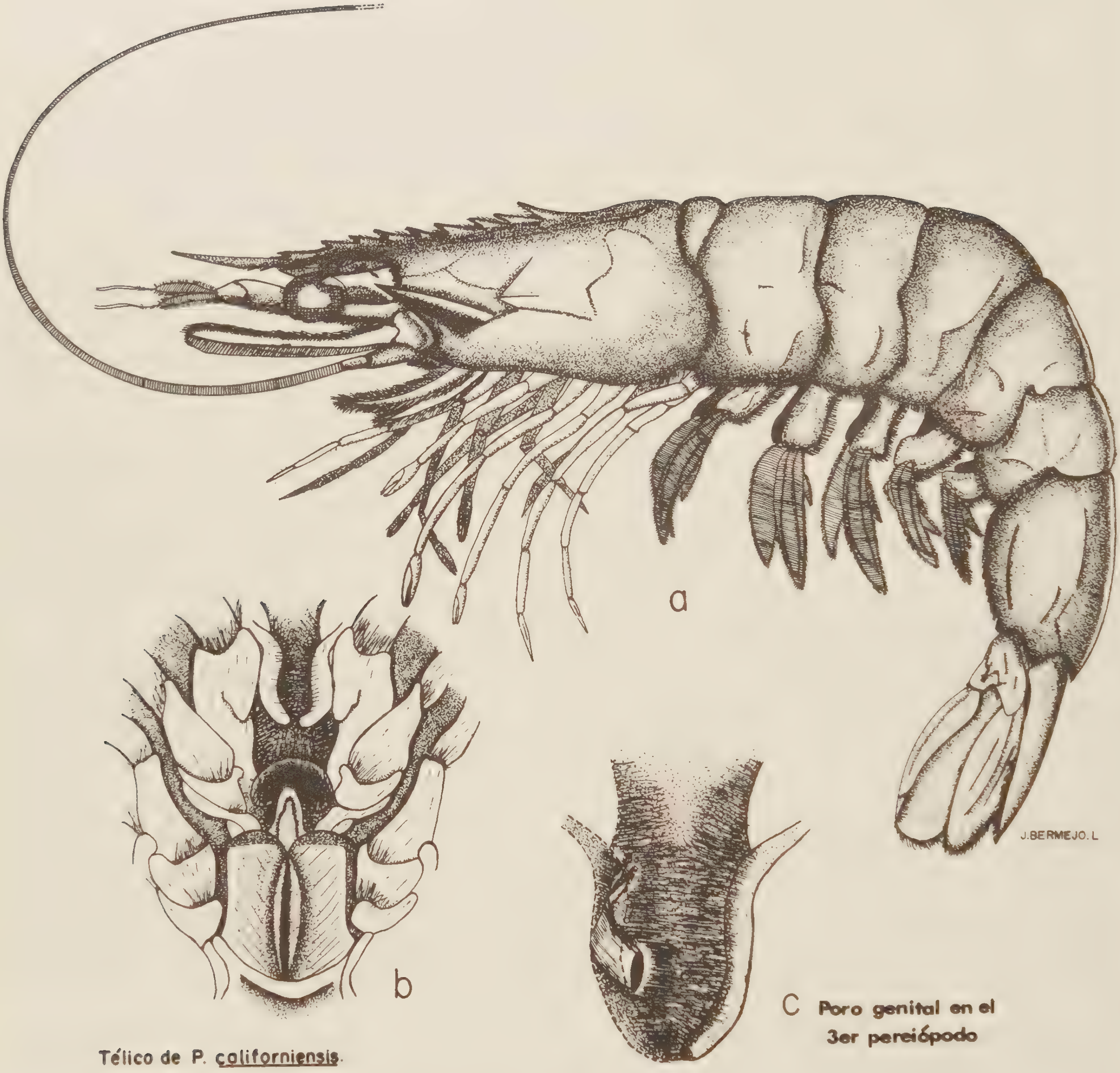
Ovulos: gametos femeninos maduros. Son células que han alcanzado total desarrollo, presentan numerosos nucléolos y unas estructuras en el citoplasma llamadas cuerpos periféricos (King, 1948), o sustancia gelatinosa (Hudinaga, 1942) (Fig. 15). Histoquímicamente no se ha determinado la naturaleza de estas estructuras; King demostró que no son de naturaleza grasa ni proteica. Miden 196 μ, aproximadamente.

Ovulos residuales: Se caracterizan por presentar núcleo degenerado, aparentemente en proceso de involución, con escasos nucléolos, encontrándose localizados básicamente en la periferia del lóbulo. Miden aproximadamente 104 μ.

4.2 Aparato reproductor masculino

El aparato reproductor masculino está constituido por un par de testículos, cada uno con un vaso deferente que se une a una ampolla terminal colocada en los coxopoditos del quinto par de pereiópodos. En esta estructura se forman los espermatóforos, que se cree salen al exterior a través del rompimiento de la membrana que forma ventralmente los coxopoditos.

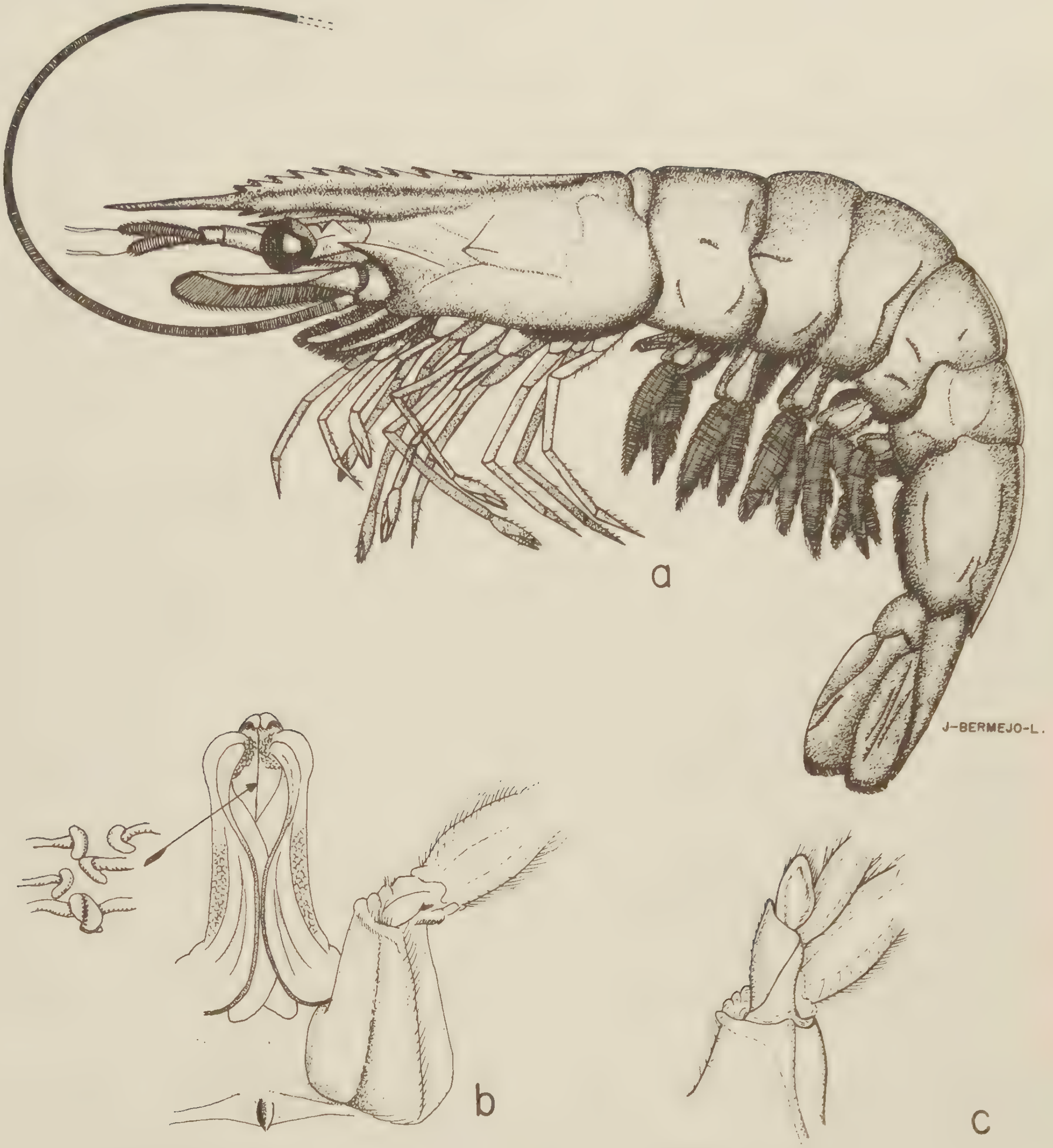
El órgano copulador del macho es el petasma (Fig. 6b) que es una modificación de los



Télico de P. californiensis.

Poro genital en el 3er pereiópodo

Fig. 5 Morfología externa de P. californiensis Holmes ♀.



Vista ventral del petasma de P. californiensis

Apéndice masculino 2ª pleópodo

Fig. 6 Morfología externa de P. californiensis Holmes ♂.

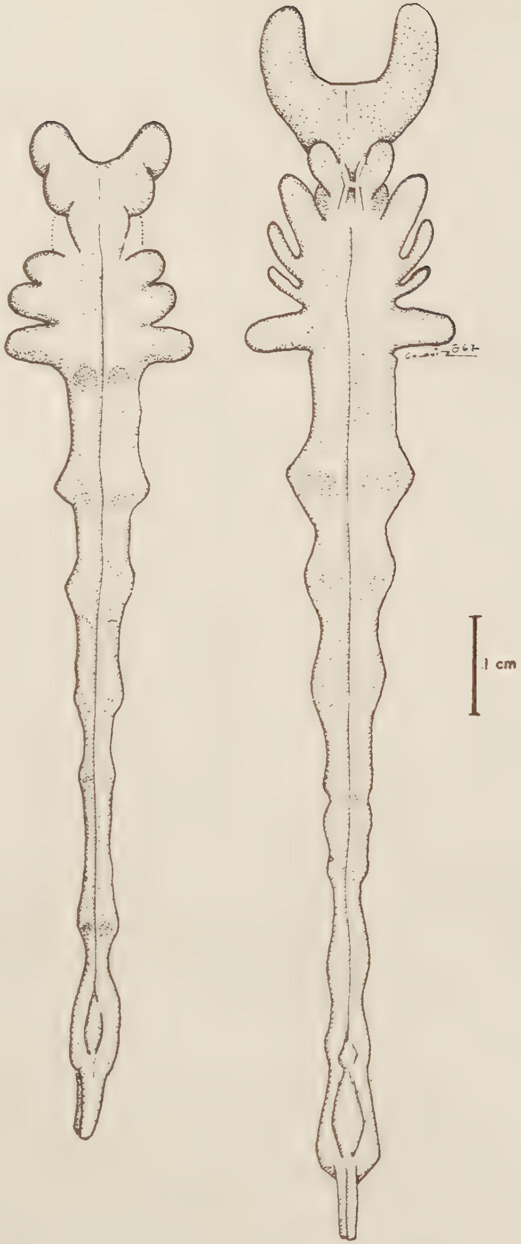


Fig. 7 Variación estacional en el ovario. Gónadas en el mes de marzo, con gran desarrollo de los lóbulos. En la Fig. 13 se observa el aspecto microscópico.

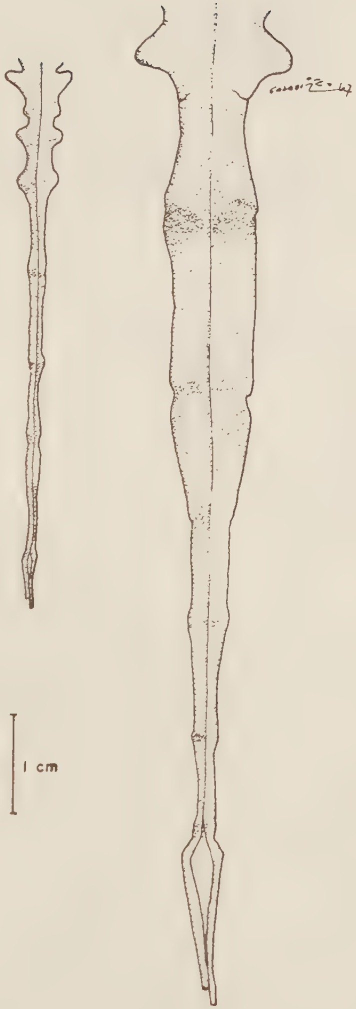


Fig. 8 Gónadas, mes de junio. Aspecto microscópico en la Fig. 16.

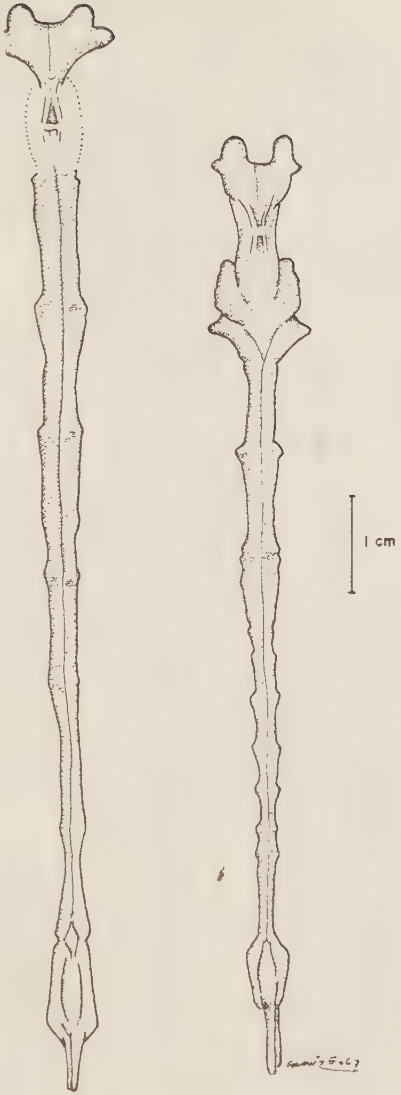


Fig. 9 Gónadas en el mes de septiembre. Detalle microscópico en Fig. 22.

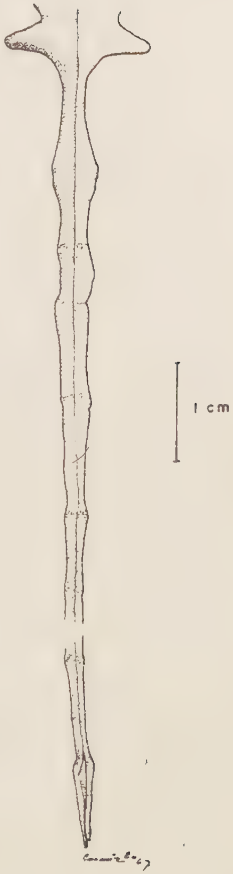


Fig. 10 Gónada, mes de diciembre. Obsérvese la Fig. 26.

endopoditos del primer par de pleópodos. Otra estructura presente en el macho, que parece tomar parte en la cópula, es el apéndice masculino (Fig. 6c), que es también una modificación del segundo par de pleópodos.

4.3 Acoplamiento

De acuerdo con observaciones realizadas en acuarios o en tanques, la cópula tiene lugar, generalmente durante la noche, sin fuente de iluminación cercana, poco después de que la hembra ha mudado. En esta etapa el macho presenta caparazón duro; sigue a una sola hembra, a la que se une ventralmente (Hudinaga, 1942) y en este momento se realiza la transferencia del espermatóforo portador de los espermatozoides. Este permanece en el receptáculo seminal de la hembra, pero al mudar ésta nuevamente, pierde también el espermatóforo, por lo que si la fecundación no se ha realizado requerirá nuevamente la transferencia del espermatóforo. Cárdenas (1952) dice que se podría pensar que los orificios genitales de la hembra permanecieran abiertos para recibir mejor la aportación de los productos sexuales masculinos a medida que los óvulos van siendo expulsados, puesto que el extremo anterior del espermatóforo queda muy próximo a tales orificios. Sin embargo, los espermatóforos permanecen en el receptáculo seminal, como se dijo antes.

5 RESULTADOS

5.1 Resultados del análisis microscópico de la gónada femenina de *P. californiensis*

Según King (1948), la evolución de la gónada en las hembras de *P. setiferus* comprende 5 estadios diferentes, que se suceden desde que la hembra se encuentra en estado juvenil hasta que alcanza la madurez total. A las distintas etapas de diferenciación corresponde un color característico, que va cambiando paulatinamente, según fue observado por Chapa (1956) en *P. californiensis*. En el caso de *P. setiferus*, King (1948) denomina los cinco estadios sucesivos de desarrollo del ovario de la siguiente manera: no desarrollado, desarrollado, amarillo, maduro y gastado. En términos generales, en las hembras de *P. californiensis* estudiadas se observaron estas cinco etapas evolutivas.

A continuación se describen, mes por mes, los cambios observados en el ciclo gonadal a lo largo del año.

Enero: En general, la gónada de los ejemplares observados presentó aspecto de completa gravidez, con el color anaranjado intenso que es característico de esta etapa. Las preparaciones histológicas mostraron que la gónada está ocupada casi completamente por óvulos residuales. Además, en algunos animales se observaron cantidades apreciables de células epiteliales germinales, más o menos organizadas dentro del folículo. En ciertos ejemplares se observaron cuerpos periféricos en el citoplasma de los óvulos que indican maduración. La Fig. 11, seleccionada para ilustrar lo que se observó en este mes, muestra óvulos de aproximadamente 100 µ de diámetro mayor.

Febrero: Macroscópicamente, el ovario presenta una estructura semejante a la del mes anterior, tanto en lo que se refiere a tamaño como a color. Microscópicamente, la característica principal es la presencia de ovocitos en crecimiento, con una organización característica en los lóbulos del ovario. Los óvulos residuales están rodeados por células nutricias; se observaron escasos óvulos con cuerpos periféricos en el citoplasma. La Fig. 12 muestra la disposición de los ovocitos, que miden aproximadamente 27 µ de diámetro mayor.

Marzo: Macroscópicamente, los ovarios no muestran grandes diferencias con respecto a lo que se observó en los meses anteriores. En términos generales tienen el mismo color anaranjado intenso, aunque el tamaño es mayor, pues ahora ocupan casi todo el espacio dorsalmente disponible en el cuerpo del animal. Histológicamente, se observó como característica principal que los ovocitos se agrupan en columna; están en activo crecimiento, presionando a los óvulos residuales hacia la periferia del lóbulo del ovario; los óvulos residuales son escasos; algunos ejemplares presentan cuerpos periféricos en el citoplasma de los óvulos. La Fig. 13 muestra el agrupamiento en columna de los ovocitos, que miden aproximadamente 45 μ; a los lados se observan óvulos residuales de 100 μ de diámetro mayor, aproximadamente, situados en la periferia del lóbulo.

Abril: Durante este mes los ovarios ocupan generalmente todo el espacio dorsal en el cuerpo del animal, aunque se observaron también ejemplares con ovarios menos desarrollados, de color amarillo claro. Microscópicamente, se sigue notando en conjunto y como característica distintiva de este mes, el crecimiento de los ovocitos; también se observan óvulos con cuerpos periféricos, y algunos óvulos residuales. En la Fig. 14 se observan óvulos maduros, con diámetro mayor aproximado de 128 μ.

Mayo: En este mes la gónada está más desarrollada; generalmente es de color anaranjado, aunque haya ejemplares que la tienen de color verdoso. Microscópicamente, se observó como característica principal que los ovocitos presentan cierto ordenamiento dentro de los lóbulos del ovario, distribuyéndose en forma circular. A semejanza de lo que se observó en los meses anteriores, se presentan zonas de epitelio germinal, con células dispuestas en forma de columna. Algunos ejemplares presentan escasos óvulos, óvulos residuales y otros con cuerpos periféricos citoplasmáticos; estos últimos son relativamente abundantes. En la Fig. 15 se observan las diferentes características mencionadas con respecto al ordenamiento de ovocitos, que miden aproximadamente 170 μ. Se observan zonas en que se disponen en columnas, siendo su diámetro de 46 μ, aproximadamente.

Junio: En la mayoría de los ejemplares los ovarios muestran coloración blanco-amarillenta, y aunque la talla es menor que el promedio de longitud total del mes de enero, se ve que el ovario es fláccido y comienza a retraerse. En los ejemplares observados, la característica típica es la presencia de grandes óvulos residuales, rodeados de ovocitos; algunos ejemplares ya habían desovado y no mostraron óvulos residuales en esta parte del lóbulo, sino solamente las paredes que los contenían. Todavía pueden hallarse ejemplares con óvulos que tienen cuerpos periféricos citoplasmáticos. En la Fig. 16 se observa la parte posterior del ovario, en su porción terminal abdominal.

Julio: Durante el mes de julio las hembras presentaron ovarios poco desarrollados de color amarillento; aunque ocupan dorsalmente todo el cuerpo del animal, su diámetro es muy pequeño. Característicamente se observa el crecimiento de ovocitos a partir de zonas de proliferación; estos ovocitos llenan espacios considerables en los lóbulos del ovario. Algunos ejemplares presentan óvulos residuales de 78 μ de diámetro, así como óvulos con cuerpos periféricos en el citoplasma. La Fig. 17 muestra la disposición de los ovocitos (de aproximadamente 30 μ de diámetro mayor) en el ovario, y en la Fig. 18 se aprecia un detalle de los ovocitos rodeados por células nutricias.

Agosto: Los ovarios, de mayor tamaño que en el mes anterior, presentan coloración amarilla, aunque algunos son anaranjados. La característica fundamental es la presencia de grandes óvulos (194 μ) con cuerpos periféricos bien desarrollados; el crecimiento de los ovocitos (138 μ) es también notable. En algunos ejemplares se observan diversos tipos de células, que diferencian zonas de proliferación del epitelio germinal y zonas de óvulos maduros. Son escasos los óvulos con núcleo involucionado durante este mes. En la Fig. 19 se observan óvulos grandes con cuerpos periféricos, así como el crecimiento notable de ovocitos. En la Fig. 20 se aprecia un detalle de varios óvulos con sus cuerpos periféricos citoplasmáticos.

Septiembre: El tamaño de la gónada es menor que en el mes anterior, de color predominantemente blanco-amarillento. La característica principal es que los ovocitos (36 μ) están en posición central y son abundantes. También se observaron óvulos con núcleo involucionado (250 μ). Algunos ejemplares muestran todavía óvulos con cuerpos periféricos en su citoplasma. En la Fig. 22 se observan los dos tipos de células descritas como características de esta etapa.

Octubre: El diámetro de la gónada femenina es mayor que durante el mes anterior, ocupa totalmente la porción dorsal y presenta color amarillo pálido. En las preparaciones se observó que los ovocitos ocupan determinadas zonas en el centro del lóbulo del ovario, pero también se presentan abundantemente óvulos residuales (210 µ) con núcleo involucionado y se ven zonas que muestran las paredes que contuvieron los óvulos. En estos ejemplares, descritos como desovados, se encuentran partes de activo crecimiento de ovocitos. En la Fig. 23 se observan óvulos con núcleo involucionado (210 µ) y los ovocitos (50 µ) llenando el lóbulo. En la Fig. 24 se observan 2 zonas diferentes, una de ovocitos en crecimiento y otra de reabsorción del tejido gonadal. Aparentemente los óvulos ya fueron expulsados de esta zona.

Noviembre: El ovario presentó también un color amarillo pálido aunque en algunos ejemplares se ha vuelto anaranjado. Los ovocitos (24 µ) han rodeado a los óvulos que quedan y los han empujado hacia la periferia del lóbulo del ovario. Los óvulos (90 µ) presentan núcleos y nucleólos abundantes. El número de óvulos presentes es relativamente grande, aunque por lo general se presentan diferentes tipos de células en diferentes grados de crecimiento. En las zonas de crecimiento se observan ovocitos dispuestos en columna. La Fig. 25 muestra estas diferentes zonas.

Diciembre: Las gónadas, en general, presentaron un color amarillo pálido. La característica fundamental es el intenso crecimiento de ovocitos en zonas restringidas de los lóbulos, aunque hay ejemplares que muestran óvulos reabsorbiéndose y otros con núcleos casi totalmente involucionados. Son escasos los ejemplares con cuerpos periféricos citoplasmáticos. En la Fig. 26 se observa el tejido gonadal reabsorbiéndose en algunas zonas y en otras el crecimiento de ovocitos que invade al lóbulo.

5.2 Resumen del ciclo gonadal

Se establecen las siguientes etapas de desarrollo gonadal:

a) Primera etapa de crecimiento de ovocitos

Comprende los meses de febrero, marzo y abril. Los ovarios son de color anaranjado, lo que no indica forzosamente madurez sexual, ya que la observación microscópica en el mes de abril mostró un incremento en el número de óvulos maduros. El crecimiento de los ovocitos se realiza a partir de zonas del epitelio germinal, observándose que aunque éstos persisten durante todo el año, hay una etapa de desarrollo de ovocitos, lo cual es más notorio en lo que se refiere al incremento en tamaño y cambio de posición que experimentan.

b) Etapa de maduración de óvulos y desove

Esta etapa comprende los meses de mayo, junio, julio y agosto. Los ovarios son de color anaranjado, que luego pasa a blanco y después a amarillo. Microscópicamente, en junio se observó un incremento en la proporción de hembras desovadas, con recuperación notable de ovocitos en julio. El ápice de esta etapa ocurre en agosto. Se refiere a la aparición de los cuerpos periféricos en el citoplasma de los óvulos. En las preparaciones microscópicas observadas se encontraron ejemplares con óvulos maduros, así como zonas de proliferación, con epitelio germinal en diferentes etapas evolutivas.

c) Segunda etapa de crecimiento de ovocitos

Se registra durante los meses de septiembre, octubre y noviembre. Los ovarios son de color blanco amarillento que pasa a amarillo, lo que indica se encuentran en una fase de crecimiento. Microscópicamente se observa un claro crecimiento de ovocitos, el cual ocurre gradualmente.

d) Etapa de degeneración de los óvulos

En los meses de diciembre y enero se observa un incremento de óvulos degenerados con núcleo involucionado, indicando que el tejido gonadal está reabsorbiéndose.

Sintetizando el proceso observado, se establece que a lo largo del año hay dos períodos claros de crecimiento de ovocitos, con otro marcado período de maduración; intermedios a estos dos se observan períodos de expulsión y de degeneración de los óvulos, haciéndose también notorio un período de recuperación celular, anterior al crecimiento de los ovocitos.

Macroscópicamente se observa que en los períodos de crecimiento de ovocitos, la gónada mantiene un color anaranjado. Durante el período de maduración, la gónada presenta una variación de color que va del anaranjado intenso hasta el amarillo.

Explicación de las Figuras 11 a 26

Fig. 11 - 91x. Enero. Gónada gastada. Ovulos en reabsorción. Obsérvese la disposición en columna de los ovocitos en el centro del lóbulo del ovario.

Fig. 12 - 91x. Febrero. Primera etapa de crecimiento de ovocitos. Nótese la organización de éstos, dentro del lóbulo del ovario.

Fig. 13 - 91x. Marzo. Ovocitos dispuestos en forma de columna, característicos de esta etapa de crecimiento. Los rodean óvulos en reabsorción que han sido empujados a la periferia del lóbulo del ovario.

Fig. 14 - 91x. Abril. Primera etapa de crecimiento de ovocitos, aunque es notorio también el aumento de óvulos maduros, como los que se aprecian en esta fotografía.

Fig. 15 - 91x. Mayo. Corresponde al inicio de la etapa marcada como maduración de óvulos.

Fig. 16 - 91x. Junio. Corte de ovario en la porción terminal mostrando una zona desovada.

Fig. 17 - 91x. Julio. Aspecto típico de un ovario en crecimiento de ovocitos. Compárese con la Fig. 12 y nótese cómo se trata de dos diferentes generaciones, por lo menos.

Fig. 18 - 226x. Julio. Detalle de la disposición que toman los ovocitos dentro de los folículos del ovario.

Fig. 19 - 91x. Agosto. Preparación histológica que representa típicamente la etapa de maduración, con óvulos maduros llenando todo el lóbulo del ovario.

Fig. 20 - 226x. Agosto. Detalle de la figura anterior; obsérvense los característicos cuerpos periféricos citoplasmáticos, índice de madurez de la gónada.

Fig. 21 - 355x. Agosto. Detalle de un óvulo, mostrando sus cuerpos periféricos.

Fig. 22 - 91x. Septiembre. Segunda etapa de crecimiento de los ovocitos. Nótese la presencia de núcleos involucionados en los óvulos en reabsorción.

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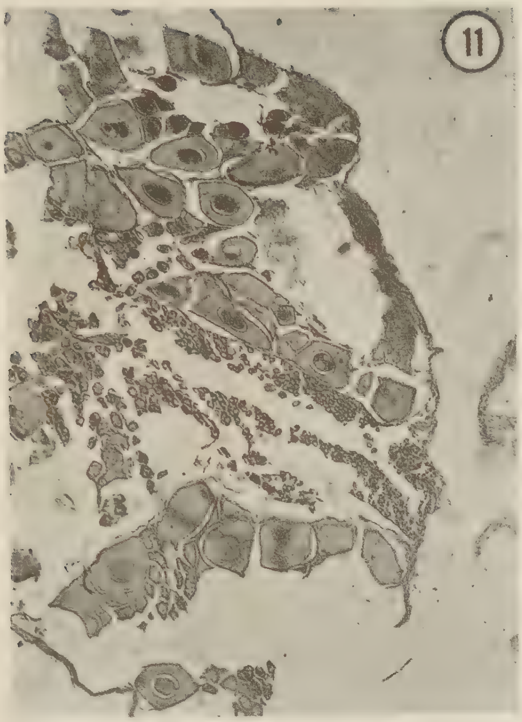
Fig. 25 - 91x. Noviembre. Ovocitos en crecimiento, rodeados por óvulos en reabsorción.

Fig. 26 - 166x. Diciembre. Gónada gastada. Obsérvese el núcleo involucionado en los óvulos en reabsorción.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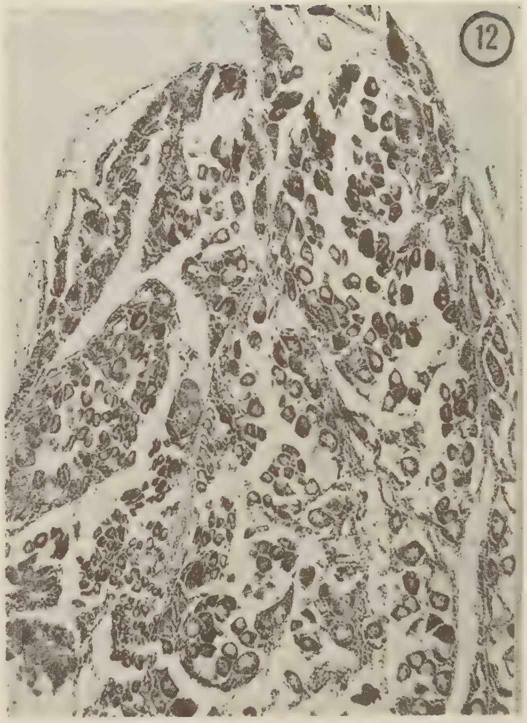
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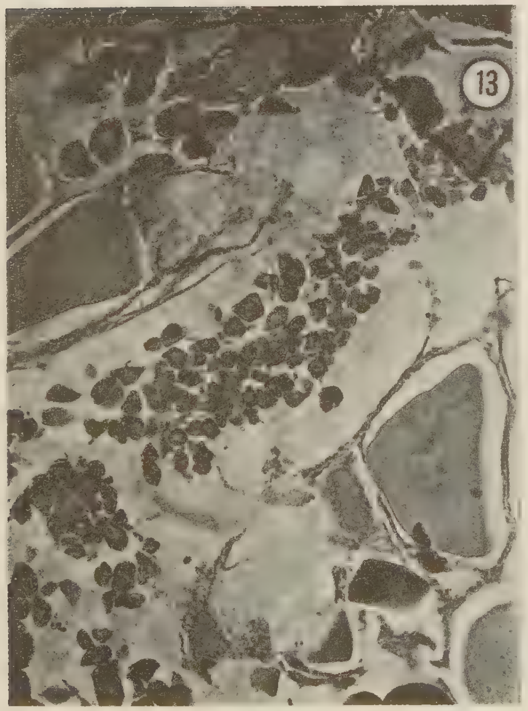
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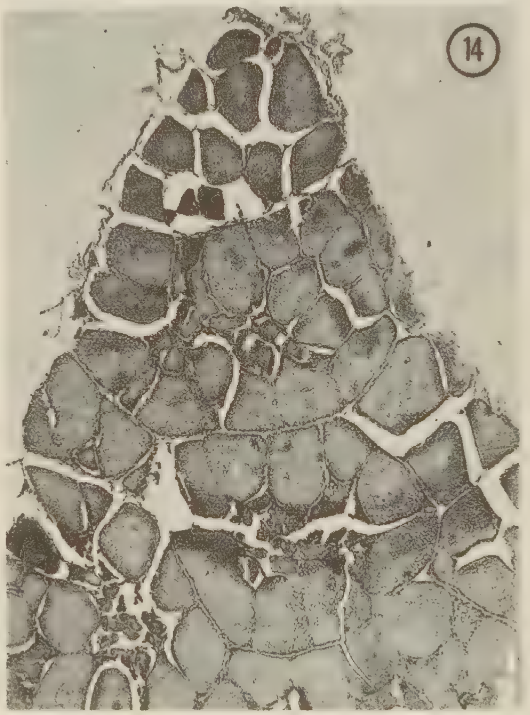
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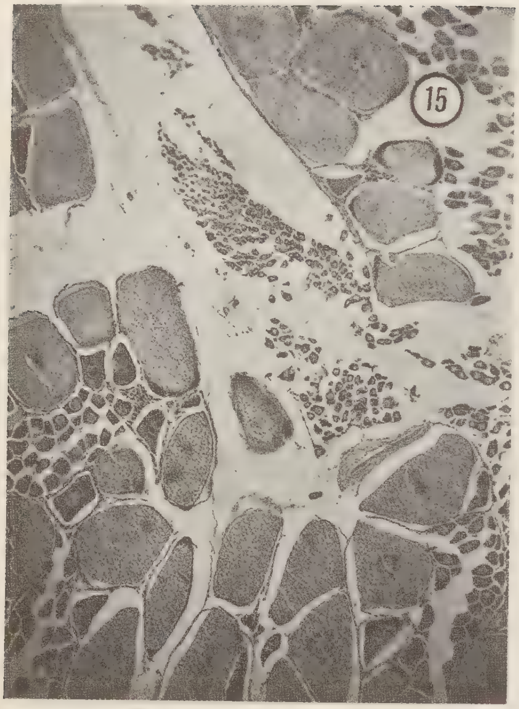
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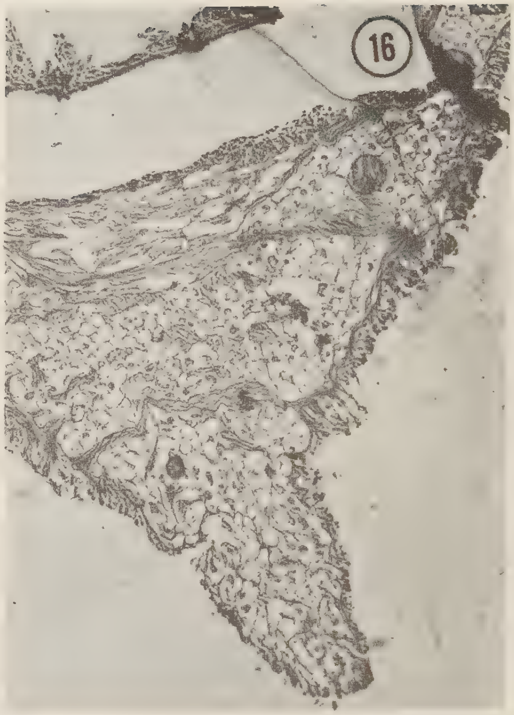
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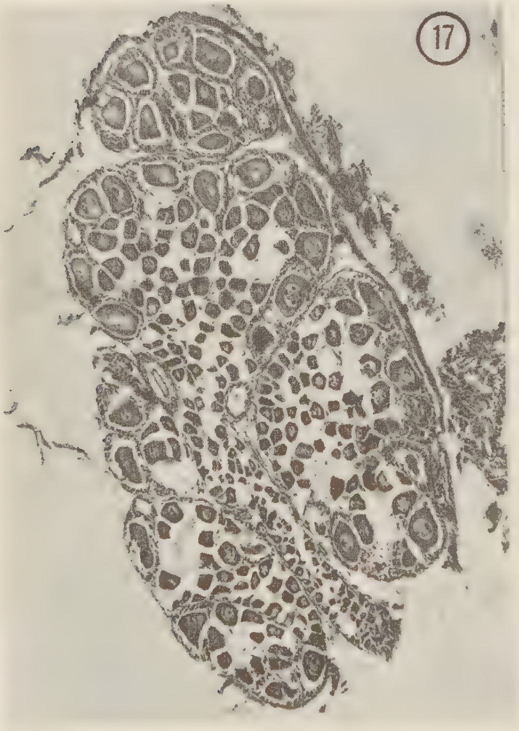
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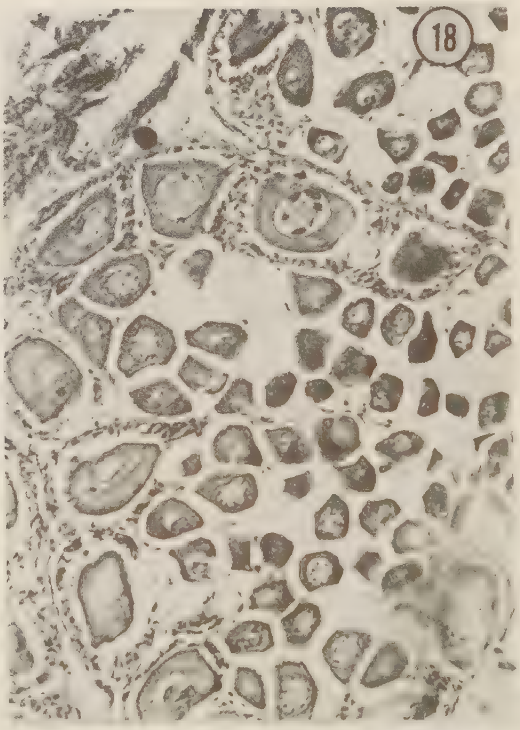
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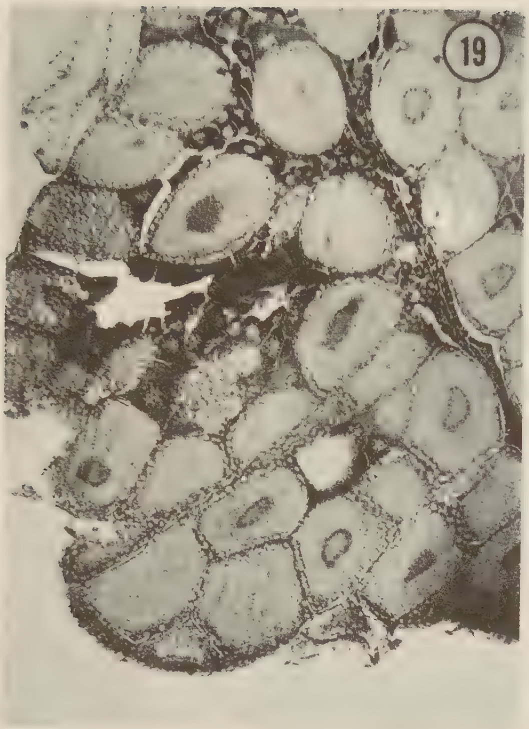

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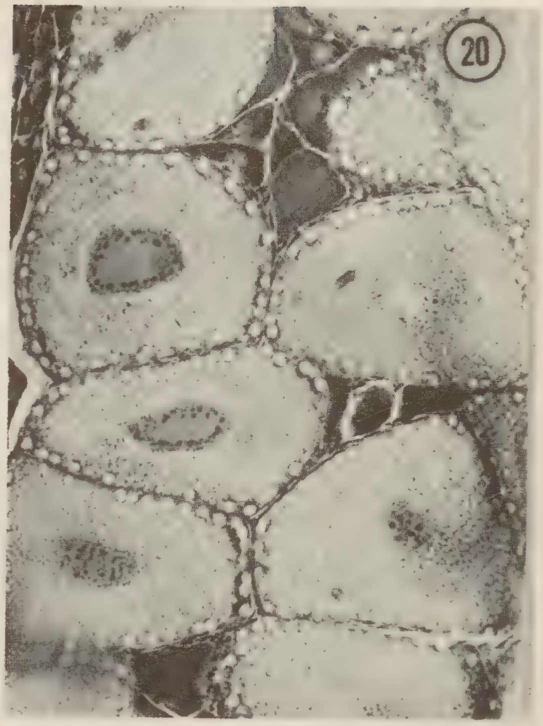

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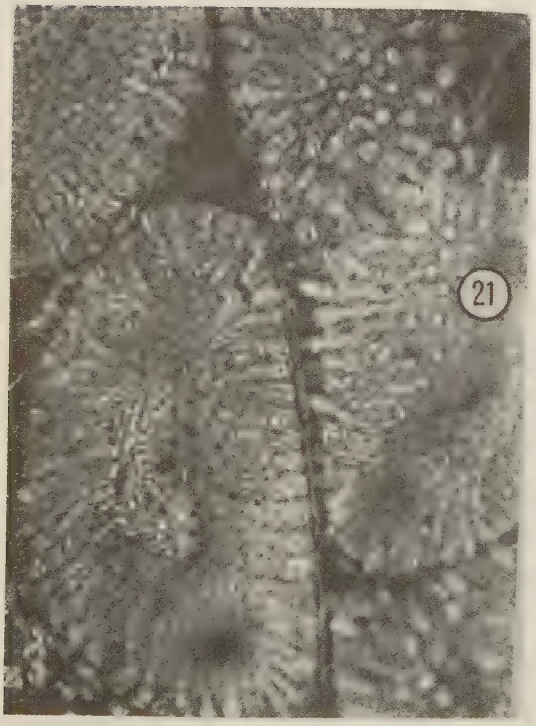

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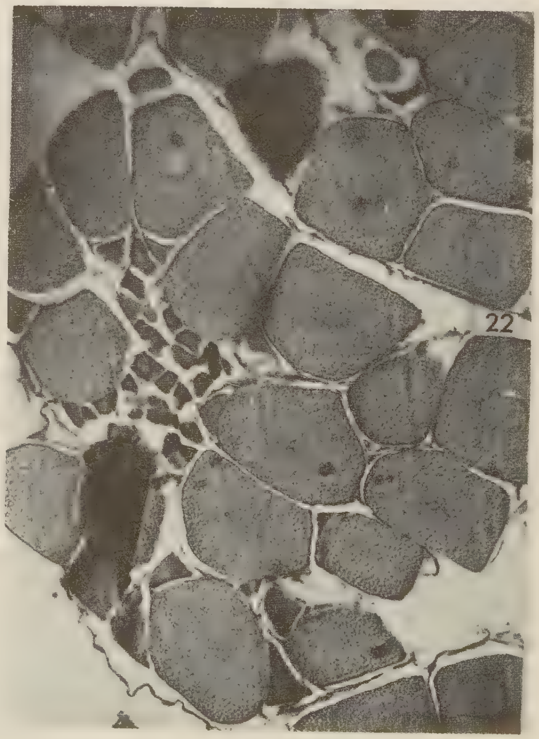

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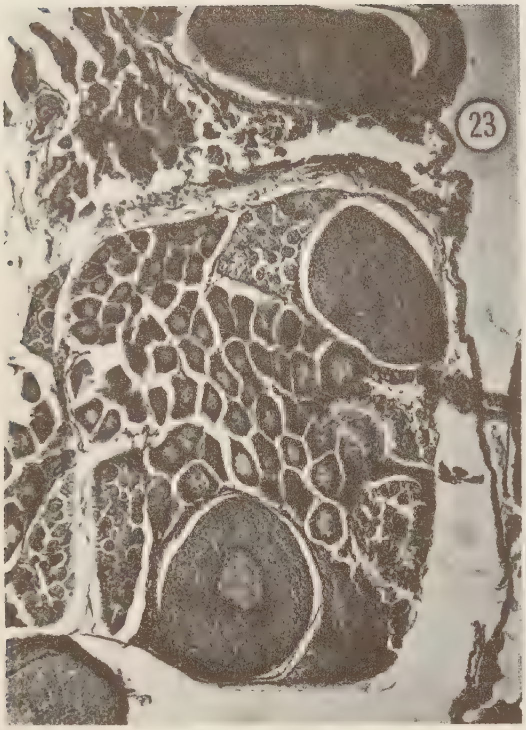

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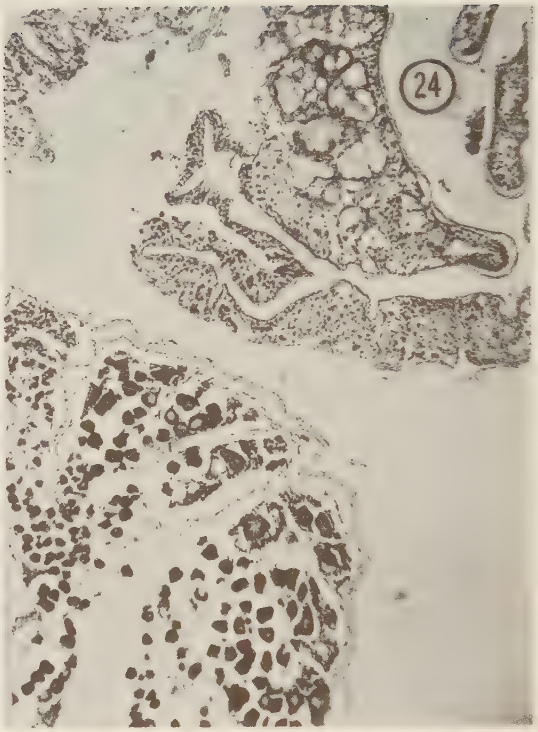

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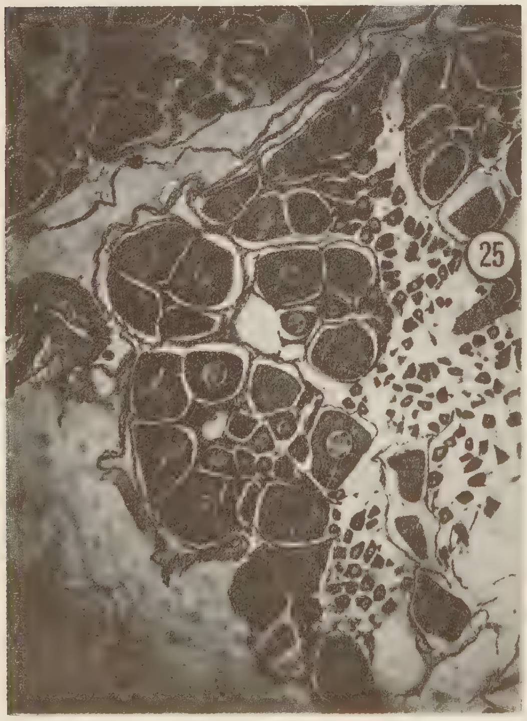

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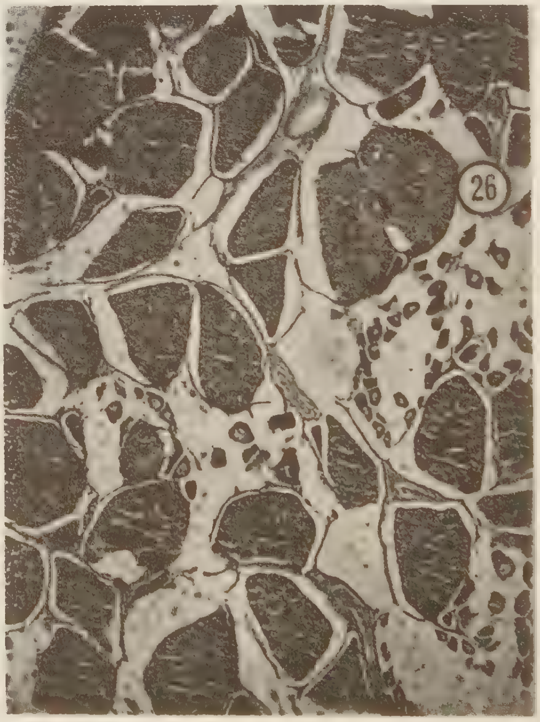

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CUADRO II

Datos condensados de las capturas analizadas

Fecha	Captura n°	Profundidad en brazas y metros	Temp.°C	Ejemplares n°	Hembras	Machos	Longitud promedio hembras mm	Etapa gonadal característica (a)	Color de la gónada fijadà (b)	Fijador usado (c)
21-8 -65	1	11(20)		32	17	15	122	M	Am	F
11-9 -65	2	17(31)	30,0	38	20	18	113	C	Ba	F
15-10-65	3	10(18)		48	25	23	117	C	Am	F
30-11-65	4	32(58)		50	27	23	116	C	Am	F
16-12-65	5	20(36)		56	30	26	116	G	Am	B
19-1 -66	6			52	24	28	133	G	A'	B
15-2 -66	7	22(40)	21,5	51	26	25	124	C	A	B
18-3 -66	8	22(40)	24,0	49	25	24	132	C	A	B
22-4 -66	9		24,)	50	30	20	137	C	A	B
24-5 -66	10			36	32	4	128	M	A	B
17-6 -66	11	11(20)	30,0	53	16	37	114	M	Ba	B
7-7 -66	12		30,0	53	29	24	105	M	Ba	B

(a) G - Gastada
C - Crecimiento de ovocitos
M - Maduración de óvulos

(b) A' - Anaranjado intenso
A - Anaranjado
Ba - Blanco amraillento
Am - Amarillo

(c) B - Bouin-Hollande
F - Formol al 10%

6 DISCUSION

El estudio de la anatomía macro y microscópica de los óganos reproductores de P. californiensis permite conocer la evolución que experimenta la gónada a través de sus diferentes etapas evolutivas.

En general, en los crustáceos es el complejo glandular localizado en el órgano X del seno glandular, el que aparentemente gobierna los ciclos reproductivos. El proceso está gobernado por hormonas gonadotrópicas producidas en el pedúnculo ocular, aunque en los camarones no se sabe si la glándula misma tiene funciones endocrinas como sucede en anfípodos e isópodos.

Como ocurre en los vertebrados, en los malacostráceos son factores genéticos los que gobiernan el desarrollo sexual de una soma indiferenciado y las células germinales, mediante hormonas sexuales. Como en los vertebrados hembras, el ovario de los crustáceos, en el momento de la producción del vitelo, secreta una hormona que prepara a la madre para la incubación (Charniaux-Cotton, 1960).

Según Giese (1959) la aparición de gametos maduros en las gónadas, es un método que permite determinar la etapa reproductora de un animal, obteniendo información citológica detallada, necesaria para definir las diferentes etapas en el ciclo gonadal. Este mismo autor compara otros métodos para determinar la estación de reproducción en algunos invertebrados marinos; tales métodos son: el desove, el número de larvas, la incubación de los huevecillos, o el tamaño relativo de las gónadas; sin embargo, se concluye que el método más seguro para determinar estaciones de reproducción en invertebrados marinos, es el desarrollado en este trabajo.

En el Cuadro II se observa la relación existente entre la apariencia macroscópica de las gónadas y la observada en las preparaciones histológicas.

Se determina que, para las localidades estudiadas, y en los ejemplares observados, en los estadios correspondientes al primer período de crecimiento de ovocitos, la glándula presentó como característica más marcada para esta etapa, un color anaranjado, índice de madurez. Esto se puede interpretar como que la glándula toma esta coloración aún antes de expulsar a los óvulos y permanece así algunos meses después de haberlo hecho. Los valores de longitud total de los ejemplares hembras observados, oscilan entre 113 y 137 mm, que corresponden a tallas de hembras adultas y no a ejemplares juveniles. Dentro de la etapa de maduración, se observó que hay relación entre la coloración de la gónada y lo que se observa en las preparaciones histológicas, puesto que en el mes de mayo se encontró una abundancia de hembras con óvulos mostrando cuerpos periféricos citoplasmáticos y, macroscópicamente, el color dominante en las hembras observadas era anaranjado, índice de madurez.

En los siguientes meses de este mismo estadio considerado, junio y julio, se registraron microscópicamente dos procesos bien marcados: desove y recuperación del tejido por un intenso crecimiento de ovocitos; macroscópicamente se observó un color blanco amarillento, índice de crecimiento de la gónada y en algunos casos relacionándola con los promedios de largos totales, se infiere inmadurez. El mes de julio presenta una relación directa, puesto que la longitud total promedio de las hembras estudiadas es 105 mm, que es el promedio más bajo obtenido en todos los meses estudiados y es cuando se encontró que el crecimiento de ovocitos es muy intenso; la coloración de las gónadas es, en términos generales, blanco-amarillenta y la longitud y diámetro de éstas son muy pequeños en relación con las hembras observadas en marzo o abril.

En el segundo período de crecimiento de ovocitos, se observó una coloración que varía desde el blanco-amarillento hasta el amarillo, presentando en estos meses (septiembre, octubre y noviembre), un promedio de longitud total de 113 a 117 mm que resulta menor que el del primer período de crecimiento de ovocitos. Esto va de acuerdo con lo observado por Cárdenas (1951), quien establece que las hembras de P. californiensis alcanzan su madurez sexual aproximadamente dentro del período de marzo a junio. Debido a que se está tratando en este estadio con hembras que no han desovado, y en el caso del primer período de crecimiento de ovocitos, se trata de hembras ya desovadas.

Dentro de la etapa de degeneración de los óvulos, la relación más directa encontrada entre las observaciones macro y microscópicas, fue en el mes de enero, en donde el promedio de longitud total de las hembras observadas resultó de 133 mm, de donde se infiere que se trata, en términos generales, de una muestra de una población que posiblemente ya había desovado.

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ENSAYO DE INTERPRETACION DE LAS TALLAS COMERCIALES DE CAMARON EN LOS LITORALES DE SONORA, MEXICO

por

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Extracto

Después de analizar las tallas de las dos especies principales que se desembarcan en las plantas de maquila en Guaymas (Sonora), los autores hacen un análisis preliminar de las vedas establecidas por la Dirección General de Pesca e Industrias Conexas.

A PROVISIONAL INTERPRETATION OF THE COMMERCIAL SIZE GROUPS OF SHRIMP ON THE COAST OF SONORA, MEXICO

Abstract

After analyzing the size groups of the two principal species of shrimp landed at the packing plants of Guaymas (State of Sonora), the authors make a preliminary examination of the closed seasons established by the Mexican Department of Fisheries.

ESSAI D'INTERPRETATION CONCERNANT LES CALIBRES COMMERCIAUX DE CREVETTES DANS LES EAUX COTIERES DE SONORA, MEXIQUE

Résumé

Après avoir analysé les calibres des deux espèces principales de crevettes débarquées dans les usines de Guaymas (Etat de Sonora), les auteurs examinent les interdictions de pêche imposées par la Direction générale des pêches.

1 INTRODUCCION

Mucho es lo que se ha discutido en los medios pesqueros de los litorales mexicanos del Pacífico y aun fuera de ellos sobre la vigencia de las vedas que el Gobierno aplica a la explotación camaronera. En especial, a partir de 1962, en que la producción sufrió una baja considerable, han venido a la capital del país diferentes comisiones con el objeto de solicitar la revisión de las reglamentaciones, esperando aumentar la captura de camarón como consecuencia de los cambios que pudieran introducirse.

2 REGLAMENTACIONES EMANADAS DE LAS AUTORIDADES DE PESCA

Los acuerdos emanados de las autoridades de pesca a partir de 1939, para reglamentar las pesquerías de camarón del Pacífico, son los siguientes (Diario Oficial de la Federación, 1939, 1947, 1951, Dirección General de Pesca e Industrias Conexas, 1946):

En un acuerdo fechado el 15 de abril de 1939, el Departamento Forestal y de Caza y Pesca, a través de la Sección de Pesca Marítima, fijó la reglamentación para la pesca de camarón en aguas protegidas y en mar abierto, como consecuencia de la introducción en el país de las redes de arrastre. La reglamentación era la siguiente:

(a) Para aguas marítimas, veda del 16 de abril al 30 de septiembre;
(b) Para las aguas salobres o "protegidas", veda del 1 de febrero al 31 de julio.

Mediante esta reglamentación se trató de proteger la reproducción y el crecimiento de las especies de camarón que para aquel entonces estaban involucradas dentro de la pesca comercial, a saber: el camarón azul (*Penaeus stylirostris*) y el camarón blanco (*P. vannamei*), ya que la pesca se realizaba principalmente en la zona sur de Sinaloa y al norte de Nayarit con el sistema de trampas estuarinas o "tapos", mientras que las embarcaciones de mar abierto pescaban únicamente en el cordón litoral que no va más allá de diez brazas (18 m) de profundidad, capturando las especies mencionadas una vez que habían salido de las aguas protegidas para completar su desarrollo y reproducirse. En particular, la reglamentación para las aguas salobres trataba de proteger el crecimiento de las especies dentro de sus viveros naturales.

A pesar del aparente empirismo en la formulación de esta reglamentación, las investigaciones continuadas durante más de 20 años han demostrado que los períodos vedados se aproximaban con bastante precisión a las épocas en las que suele haber mayor abundancia de camarón pequeño.

Un acuerdo posterior de la Dirección General de Pesca, ya dentro de la Secretaría de Marina, publicado el 18 de abril de 1947, cambió la reglamentación anterior, estableciendo una nueva veda para las aguas protegidas de Mazatlán hacia el norte, del modo siguiente:

(a) Aguas protegidas: De Mazatlán hacia el sur, veda del 1 de febrero al 31 de de julio. De Mazatlán hacia el norte, incluyendo los litorales de Sonora y el oriental de ambos territorios de Baja California, un primer período de veda del 1 de marzo al 15 de abril y un segundo período del 1 de junio al 31 de julio.

(b) Aguas marítimas: Comprendidos los litorales de Nayarit, Sinaloa, Sonora y los orientales de ambos territorios de Baja California, veda del 1 de agosto al 30 de septiembre.

Este nuevo acuerdo trató, al parecer, de separar las aguas protegidas en dos zonas, tomando como punto de partida el Puerto de Mazatlán, tal vez atendiendo a la distribución geográfica aparente de las dos especies involucradas en la pesca de aguas protegidas, o sea, el camarón azul de Mazatlán hacia el norte, y el blanco hacia el sur. En todo caso, el objeto, como en el caso anterior, era el de proteger el crecimiento y desarrollo de las poblaciones mientras permanecían en la zona estuarina.

Por otro lado la veda de aguas marítimas sufrió un cambio interesante, ya que fue puesta del 1 de agosto al 30 de septiembre. Aparentemente las autoridades ya habían adoptado el criterio de que, por tratarse de especies de alto potencial reproductivo, no era el caso, como se pensaba antes, de proporcionar una protección especial a las hembras en desove, pero sí se mantuvo en pie la política de dejar el recurso sin explotar durante el período inmediatamente después, cuando se suponía que era necesario dejarlo crecer a tamaños más comerciales.

Téngase en cuenta que hasta entonces la pesquería comercial de camarón se basaba en las especies azul y blanco.

Otro acuerdo, fechado el 16 de julio de 1951, fijó nuevamente cambios a la veda en mar abierto, reduciéndola únicamente para el mes de agosto.

Para estas fechas, los estudios realizados en el Instituto de Pesca del Pacífico, establecido en Guaymas, Sonora, y sostenido por los armadores y camaroneros, estaban bastante avanzados (Inst. Pesca del Pacífico, 1949, 1950; Núñez y Chapa 1950, 1951, 1951a). También para entonces una tercera especie de camarón comercial, el café (Penaeus californiensis), era pescada en masa por la flota en profundidades mayores (Chapa, 1956).

La reducción de la veda al mes de agosto, trajo por consecuencia que los pescadores arrojaran al mar gran cantidad de camarón de tallas pequeñas, debido tal vez a la falta de precio en el mercado de exportación para estas tallas.

En 1954, la Dirección General de Pesca, basándose en los estudios de desove y madurez sexual, fijó un nuevo período de veda en la primavera (entre marzo y abril), aparte de los meses de veda de verano (16 de julio a 15 de septiembre) que protege el crecimiento de las poblaciones que salen desde las aguas protegidas. Estas medidas no contaron con la aprobación de la industria, que se opuso terminantemente a su aplicación en la temporada siguiente.

No ha sido posible conseguir los antecedentes relacionados con la reglamentación que desde entonces se ha venido aplicando al camarón en el Pacífico, estableciendo las vedas siguientes:

(a) Para aguas marítimas, veda del 16 de julio al 15 de septiembre;
(b) Para aguas protegidas, veda del 16 de abril al 31 de julio.

En la práctica, el inicio de las actividades de pesca es determinado por la Dirección General de Pesca tomando como base el resultado de los muestreos que se efectúan tanto en mar abierto como en las aguas protegidas, aunque a decir verdad, la presión que sobre las autoridades ejercen los intereses creados por una industria tan valiosa, ha sido determinante en la fijación de estas fechas.

Sin embargo, se ha creído pertinente atender las demandas de los pescadores cooperativistas en el sentido de efectuar una revisión a las reglamentaciones, ya que ellos, por tener las especies de camarón comercial reservadas por Decreto Gubernamental, por su larga experiencia en la pesca del crustáceo y por ser autores y testigos de la destrucción de aquellos ejemplares que por su pequeñez son arrojados ya muertos al mar mientras no exista mercado para los mismos, conocen los hechos reales de la pesca.

Para la elaboración de este trabajo nos hemos servido de parte de los datos de la producción de camarón maquilada en el Puerto de Guaymas, Sonora, considerando que aproximadamente el 80 por ciento de la producción de camarón de ese Estado es descargado allí. La información ha sido conseguida por el personal de la Estación de Biología Pesquera establecida por el Instituto Nacional de Investigaciones Biológico-Pesqueras en aquel puerto, de datos provenientes de la planta conocida como Congeladora Cooperativa de Guaymas en Copropiedad.

El área de pesca de la flota de Guaymas se extiende desde el litoral oriental de Baja California Norte, entre San Felipe y la desembocadura del Río Colorado, hasta las costas de Sonora y del norte de Sinaloa. Ocasionalmente las embarcaciones pescan en pequeñas áreas situadas al sur de San Felipe hasta la altura de Bahía Concepción, Baja California.

La desembocadura del Río Colorado y una zona cercana, limitada por una línea que se extiende desde Bahía Ometepec, Baja California, hasta la desembocadura del Arroyo de Santa Clara en Sonora, está permanentemente vedada a todo tipo de explotaciones pesqueras, por considerarse como el criadero de la valiosa especie de escama conocido con el nombre de totuaba (Cynoscion macdonaldi), así como del camarón azul y de otras especies comerciales, aunque a decir verdad se ignora si esta veda produce efectos económicos positivos, y la disposición es violada constantemente por falta de vigilancia.

En este ensayo se han tratado de resumir, de manera preliminar, los datos de las últimas cinco temporadas de pesca, a saber: 1962/63, 1963/64, 1964/65, 1965/66 y 1966/67 hasta el momento de la elaboración, o sea, desde que la industria pesquera se declaró en crisis entre las temporadas de 1962/63 y 1963/64.

No se discuten aquí las razones que dieron origen a la crisis, pues es sabido que el éxito de la pesca como negocio está sujeto a multitud de factores, entre los que no hay que olvidar el factor precio y la importancia de la demanda en el mercado de los Estados Unidos de América. Además, téngase en cuenta que en la pesquería comercial de Sonora se encuentran involucradas dos especies principales que son el camarón café y el azul, y otras dos secundarias y ocasionales: el blanco y el rojo. Naturalmente, existen diferencias muy importantes en la biología y comportamiento de cada una de ellas, que afectarían a la aplicación de medidas proteccionistas. Además, el camarón azul soporta en los litorales de Sonora desde hace más de treinta años una pesca organizada en aguas protegidas (Ferreira, 1965).

Con objeto de que se tenga una idea de las variaciones que la producción descargada en Guaymas ha sufrido en las temporadas aquí consideradas, en el Cuadro I se han sumarizado los datos correspondientes a la producción descargada en el puerto, el número de viajes realizados por la flota y el promedio del rendimiento por viaje.

CUADRO I

Producción de camarón descargada en Guaymas en las últimas cuatro temporadas, viajes realizados por la flota y rendimiento

Temporada	Producción descargada kg	No. de viajes	Rendimiento por viaje kg
1962/63	6.974.180	3.107	2.244
1963/64	6.320.984	3.690	1.713
1964/65	5.252.996	3.751	1.400
1965/66	5.765.740	3.477	1.658

En cuanto a las variaciones en los rendimientos mensuales de los viajes realizados, estos detalles se darán a conocer en publicaciones posteriores, pero en resumen se puede considerar que en el mes de septiembre, al comenzar la temporada, los viajes dan un alto rendimiento en virtud de que las poblaciones de camarón estuvieron en reposo durante los dos meses de veda, aunque no es posible, por falta de pesca en aquellos meses, saber si el efecto integral de la veda es económicamente positivo en comparación con una pesca ininterrumpida.

Además de productivos, los viajes son cortos debido a la poca vida del hielo de las bodegas, originada por el calor. En cambio, durante el invierno los viajes rinden menos y al mismo tiempo son más largos, situación que se prolonga hasta la primavera siguiente.

Como en este trabajo se manejan datos de camarón descabezado, la clasificación adoptada es la que se ha generalizado en el mercado extranjero, donde la mayor talla comercial se conoce como U-10 (diez colas o menos por libra americana, o sea, 22 por kg), mientras que el menor tamaño que se reconoce corresponde al peso de 71 a 80 colas por libra (156 a 176 por kg).

La cabeza del camarón (cefalotórax) representa aproximadamente el 35 por ciento de la talla total del camarón café y el 25,3 por ciento del camarón azul, mientras que esta parte constituye aproximadamente el 40 por ciento del peso en ambas especies.

En el Cuadro II se especifican las tallas comerciales y sus correspondientes tamaños del animal entero y de su abdomen (cola).

CUADRO II

Tallas comerciales de camarón y sus correspondiencias en milímetros del ejemplar entero y del abdomen

Tallas comerciales		Tamaño promedio total mm	Tamaño promedio del abdomen mm
GRANDE	U-10	171,0	132,0
	U-12	161,0	124,6
	U-15	152,0	116,7
	16-20	140,0	108,1
	21-25	130,0	100,9
	26-30	123,0	94,5
CHICO	31-40	116,0	89,3
	41-50	106,0	81,8
	51-60 o más	91,0	70,0

3 ANALISIS

Para el manejo de los datos, hemos considerado en primer termino (Cuadro II), que en el comercio se toman como "tallas chicas" de camarón aquellas que no van más allá de 31 a 35 ejemplares por libra (68 a 77 por kg, descabezado), que corresponden a 116 mm de longitud total o menos; y como "tallas grandes" las de 26 a 30 camarones por libra (57 a 66 por kg, descabezado), o menos, que corresponden a 123 mm de longitud total o más. En otras palabras, basándonos en la terminología empírica de la industria constituida por las cooperativas, se supone en este primer ejemplo que la talla mínima comercial sea en la línea divisoria entre "camarón chico" (31 colas o más por libra) y "camarón grande" (30 colas o menos), y luego se compara la situación si este parámetro se establece al nivel de 50 y 70 colas, respectivamente.

Del análisis de los Cuadros III, IV y V, así como de las Figuras 1, 2, 3 y 4, se pueden sacar temporalmente algunas conclusiones sobre la biología y comportamiento de las dos especies de camarón comercial que pesca la flota de Guaymas, a saber:

CUADRO III

Porcentaje de dominancia de las especies en la pesca comercial de la flota de Guaymas, Sonora

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio		Julio	
	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.	P. s.	P. c.
1962 a 1963	87,32	12,65	47,08	52,89	33,23	66,75	8,61	91,36	0,94	99,03	7,65	92,33	13.97	86,00	9,68	90,30	13,04	86,94	5,17	94,81	3,25	96,68
1963 a 1964	75,49	24,50	40,56	59,42	15,66	84,27	5,96	94,02	4,74	95,24	3,88	96,10	9,66	90,33	5,83	94,15	6,07	93,91	0,50	99,48	2,67	97,31
1964 a 1965	63,70	36,28	54,29	45,69	13,89	86,05	4,15	95,82	5,59	9 , 39	5,46	94,52	13,73	86,26	6,97	93,01	3,65	96,31	0,46	99,51	2,22	97,76
1965 a 1966	40,81	59,17	21,72	78,26	12,77	87,16	8,54	91,37	6,90	93,09	4,34	95,64	7,70	92,28	8,56	91,41	4,86	95,10	1,14	98,80	0,09	99,88
1966 a 1967	26,93	73,04	12,00	87,99	8,87	91,10	10,70	89,27														

P. s. = *P. stylirostris*

P. c. = *P. californiensis*

CUADRO IV

P. stylirostris. Porcentajes de tallas "grandes" y "chicas" en desembarques de Guaymas, asumiendo t_ρ en 30 colas/libra

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio		Julio	
	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.
1962 a 1963	71,9	28,0	87,1	12,9	90,2	9,8	91,2	8,7	98,3	1,7	99,8	0,1	100,0		100,0		100,0		100,0		100,0	
1963 a 1964	80,7	19,3	81,4	18,6	87,3	12,6	81,4	18,6	86,1	13,9	100,0		100,0		100,0		100,0		100,0		100,0	
1964 a 1965	71,4	28,6	88,4	11,6	87,3	12,6	81,4	18,6	86,1	13,9	98,6	1,4	100,0		100,0		100,0		100,0		100,0	
1965 a 1966	83,6	16,4	89,9	10,1	84,0	16,0	80,1	19,9	98,1	1,9	97,9	2,1	100,0		100,0		100,0		97,3	2,7	43,8	56,2
1966 a 1967	71,3	28,7	57,4	42,6	55,2	44,8	89,4	10,6														

CUADRO V

P. californiensis. Porcentajes de tallas "grandes" y "chicas" en desembarques de Guaymas, asumiendo t_ρ en 30 colas/libra

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio		Julio	
	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.
1962 a 1963	37,2	62,8	46,6	53,3	37,3	62,7	50,3	49.3	50,6	49,3	15,7	86,4	51,9	48,1	78,4	21,6	71,3	28,7	66,1	33,9	69,2	30,8
1963 a 1964	40,2	59,8	27,2	72,8	33,8	66,1	50,9	49.1	63,9	36,1	69,4	30,5	70,9	29.1	74,2	25,8	65,8	34,1	54,7	45,2	46,2	53,8
1964 a 1965	39,0	61,0	42,1	57,8	41,5	58,5	42,4	57,5	56,7	43,3	48,0	52,6	49,7	50,3	52,5	47,5	49,2	50,7	45,5	54,5	39,5	60,4
1965 a 1966	28,2	71.7	34,6	65,3	35,8	64,2	41,1	58,9	56,1	43,9	59,7	40,3	69,1	30,9	74,9	25,1	52,5	47,4	35,0	65,0	26,3	73,8
1966 a 1967	14,6	85,3	22,8	77,2	26,3	73,7	37,6	62,3														

G = Camarón grande: 30 camarones por libra o menos

Ch = Camarón chico: 31 camarones por libra o más

(i) Se comprueba que la pesca comercial de mar abierto se realiza sobre poblaciones de camarón azul que comparten dos ambientes físicos: las aguas salobres litorales y el mar abierto (Fig. 1).

(ii) Que al comienzo de la temporada hábil de captura (septiembre a diciembre), la flota captura camarón azul que está reclutándose desde las aguas protegidas, aunque los porcentajes de estas poblaciones de talla chica son menores que los de tallas grandes (Cuadro IV).

(iii) Que a partir de enero, la pesca comercial de camarón azul se realiza sobre poblaciones casi en su totalidad adultas, aunque existe un pequeño remanente de poblaciones de talla menor (Fig. 3).

(iv) Que el crecimiento del camarón azul es extraordinariamente rápido en mar abierto entre septiembre y octubre. Aparentemente se detiene entre noviembre y diciembre para comenzar nuevamente en enero. Sería interesante relacionar estos hechos con las temperaturas marinas.

(v) Que existen poblaciones de camarón café, de todas las tallas, disponibles en la pesca comercial durante toda la temporada (Fig. 2).

(vi) Que puede considerarse al camarón café como una especie oceánica.

(vii) Que las poblaciones de camarón café de tallas "chicas" dominan desde septiembre a diciembre y vuelven a dominar al finalizar la temporada hábil entre junio y julio (Cuadro V).

(viii) El camarón café está en íntima relación con los cambios en las condiciones oceánicas, experimentando diferencias muy marcadas en su comportamiento durante las temporadas de estudio (Fig. 3).

(ix) El crecimiento del camarón café se detiene también, de manera aparente, entre diciembre y enero.

Tomando en cuenta que la separación de "camarón chico" y "camarón grande" al nivel de 30/31 colas por libra es arbitraria y que existen mercados (aunque a precios descendentes) para las tallas menores, se presenta en los Cuadros VI, VII, VIII y IX un análisis de los porcentajes de "camarón chico" para ambas especies, en la suposición de que el tamaño mínimo comercial promedio (t_ρ de Kutkuhn, 1962) sea: (a) de 50 colas por libra (110 por kg), cifra adoptada por Ingle (1961) e incorporada en la reglamentación pesquera del Estado de Florida, Estados Unidos de América; y (b) de 70 colas por libra (154 por kg), tamaño mínimo comercial que establece Kutkuhn (1962) para todas las situaciones reinantes en el mercado de los Estados Unidos de América excepto cuando la mortalidad natural sea extremadamente leve.

4 CONCLUSIONES

En vista de que los estudios sobre los aspectos biológicos (reclutamiento y mortalidad, tanto natural como de pesca); económicos (investigación del mercado en cuanto a aceptabilidad de tallas); y tecnológicos (posible reglamentación de las mallas) quedan por hacer, aún no es posible llegar a conclusiones firmes en cuanto a los verdaderos efectos de la veda actual y sus posibles modificaciones. Se espera que se puedan aclarar estos aspectos en publicaciones futuras.

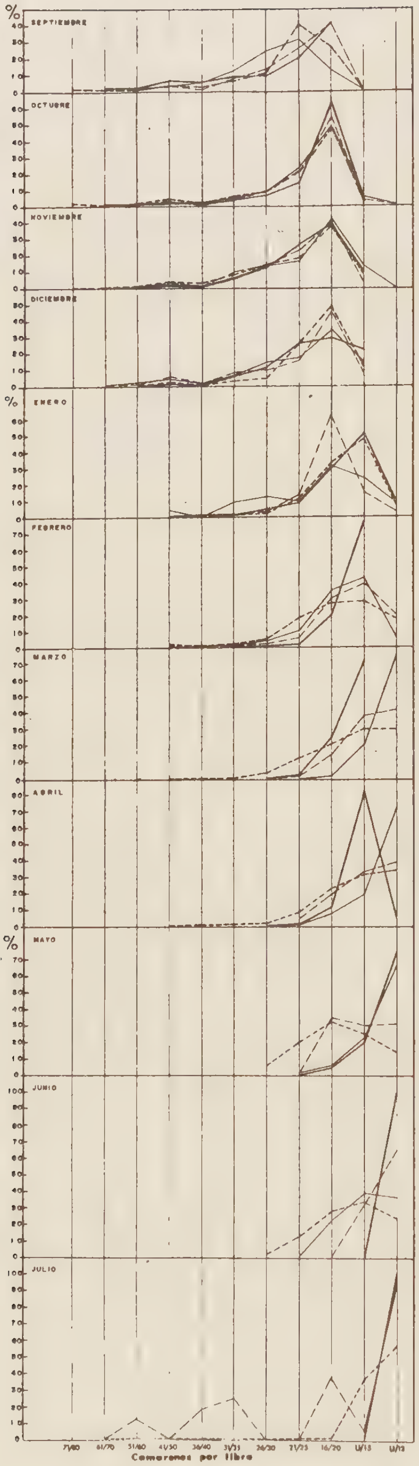

FIG. 1 Datos de maquila de la flota de Guaymas, Sonora - Penaeus stylirostris.

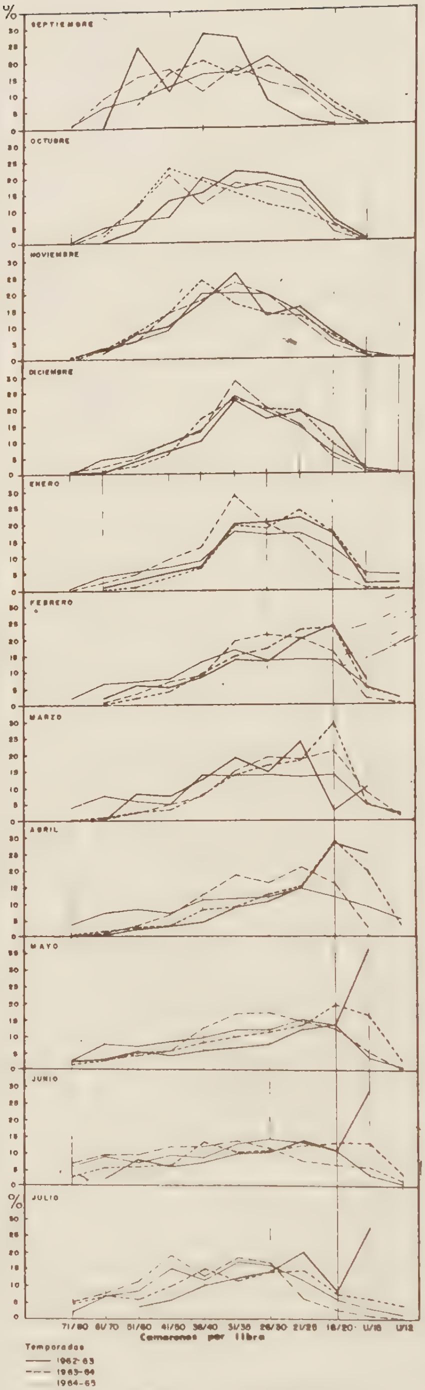

FIG. 2 Datos de maquila flota de Guaymas, Sonora - Penaeus californiensis.

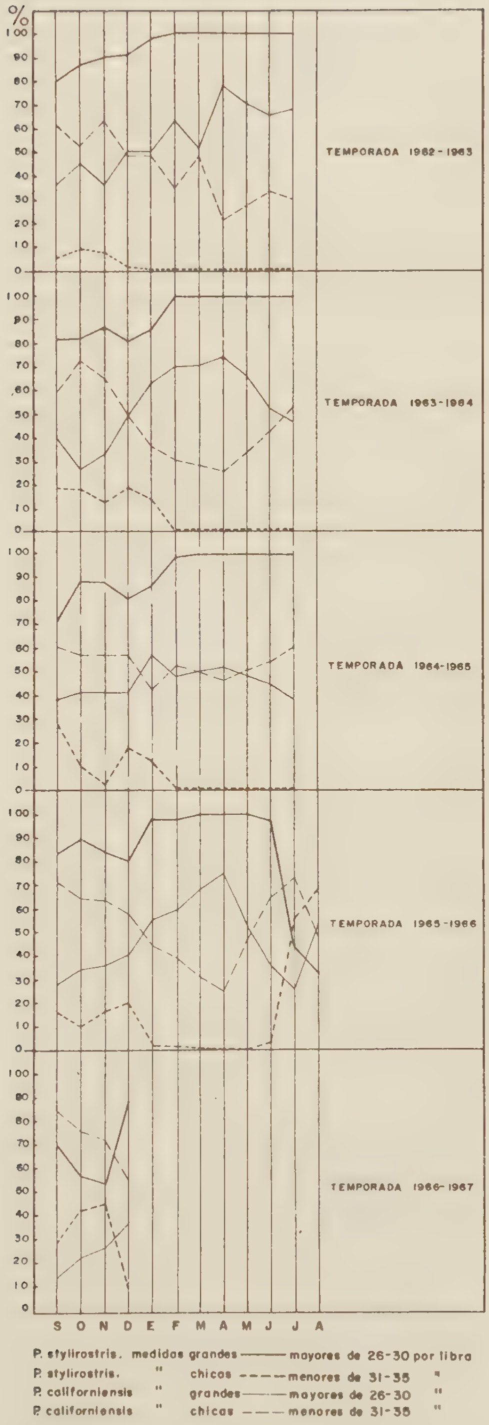

FIG.3 DATOS DE MAQUILA PROCEDENTES DEL CAMARON CAPTURADO POR LA FLOTA DE GUAYMAS, SONORA.

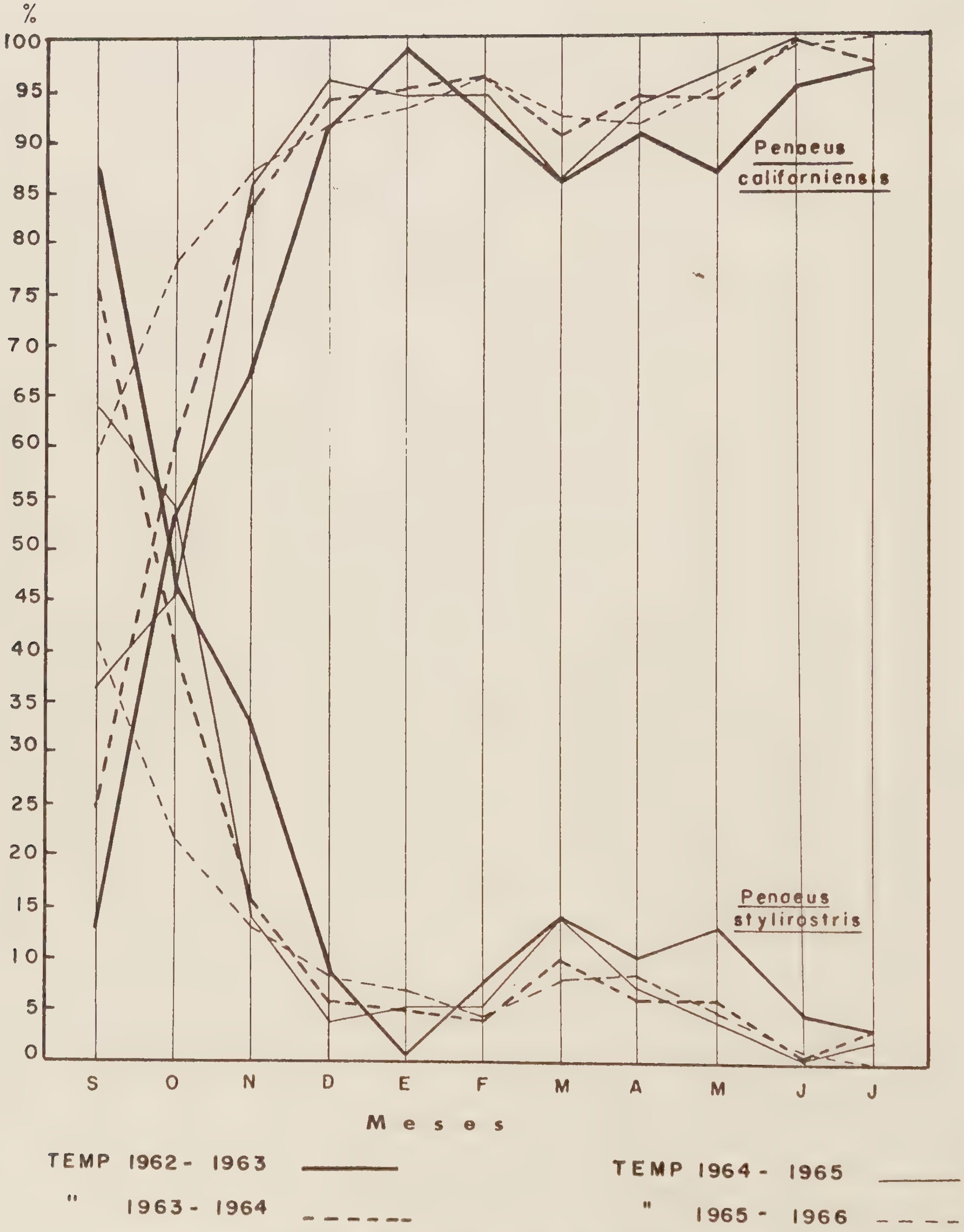

FIG.4 Dominancia de especies en la maquila de camarón de alta mar, puerto de Guaymas, Sonora.

4.1 Camarón azul

Se supone que la veda actual, que la Dirección General de Pesca e Industrias Conexas fija entre el 16 de julio y el 15 de septiembre de cada año para la pesca en mar abierto, pretende proteger el crecimiento de las poblaciones que salen durante el verano desde las aguas protegidas, ya que en las temporadas consideradas en este trabajo, el porcentaje de tallas "pequeñas"* raras veces pasó de 25 por ciento y nunca de 50 por ciento (Cuadro IV), existiendo claro dominio de tallas "grandes" en todos los meses de pesca hábil.

Aun si se considera que en ocasiones, al comenzar la temporada (mes de septiembre), son devueltas al mar cantidades importantes de camarón cuyo tamaño no permite siquiera su descabezamiento, esto no fue más allá del 10 por ciento de la captura de la especie.

Es necesario recordar que la especie está sometida a intensa pesca en las aguas protegidas donde las post-larvas han penetrado para desarrollarse. Esta pesca, que comienza generalmente a fines de agosto, se efectúa totalmente sobre poblaciones en franco desarrollo y crecimiento, con excepción de casos aislados de migración inversa formada por poblaciones adultas que penetran en aguas profundas como Guaymas en Sonora y Topolobampo y Altata en Sinaloa.

Hasta que no se realicen estudios de mortalidad la Dirección General de Pesca no estará en condiciones de poder dictaminar, sobre bases racionales, una disminución en la pesquería de aguas protegidas, ya que el tomar una medida radical ahora sin existir pruebas que demuestren que la mortalidad natural y por predación dentro de las aguas protegidas sea menor a la ocasionada por la pesca comercial, podría tener efectos socioeconómicos poco deseables.

Por lo tanto, se cree sea razonable la veda actual en aguas salobres para proteger el crecimiento del camarón azul, aunque no sea definitiva en virtud de que la otra especie (el camarón café) domina en las descargas totales con más de un 85 por ciento y como se verá a continuación, existen algunas aparentes anomalías que se deben tomar en cuenta para cualquier cambio en la reglamentación (Cuadro III).

4.2 Camarón café

El análisis de los datos nos muestra que las poblaciones de talla "chica" (31 a 35 o más camarones por libra), dominan en la captura comercial en los meses de septiembre, octubre, noviembre, y en ocasiones hasta en parte del mes de diciembre, existiendo dominio de tallas "grandes" en los meses restantes de pesca hábil. A partir del mes de junio, aparecen nuevamente las poblaciones de talla "chica" en proporciones que tienden a ser mayores del 50 por ciento. Es en esta época cuando los pescadores, suponiendo que están capturando ejemplares en franco crecimiento, llaman la atención de la Dirección General de Pesca (Cuadro V). Como se ve en los Cuadros VII y IX, esta supuesta situación cambia radicalmente si el criterio en cuanto a tallas "chicas" se establece en 50 ó 70 colas por libra en vez de 30.

4.3 Especie dominante en las capturas

Al comenzar la temporada hábil de pesca, el 16 de septiembre de cada año, la mayor parte de las descargas son a base de la especie azul, pues en las primeras de las tres temporadas aquí estudiadas, el dominio de la azul sobre la café es clara (Cuadro III): 87,32, 75,49 y 63,70 por ciento. Es notable sin embargo que en las últimas temporadas la especie café dominó sobre la azul, aun en el inicio de la pesca. Esto, que podría entenderse como una consecuencia de sobrepesca de camarón azul, puede quizá deberse a éxitos tardíos en el desove del camarón café, originados tal vez por cambios oceanográficos que será interesante estudiar antes de sacar conclusiones

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* es decir, de 31 colas o más por libra.

CUADRO VI

P. stylirostris. Porcentajes de tallas "grandes" y "chicas" en desembarques de Guaymas, asumiendo t_ρ en 50 colas/libra

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio		Julio		Agosto	
	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.
1962 a 1963	93,8	5,2	96,0	4,0	99,7	0,3	99,6	0,3	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100.0	0,0	100,0	0,0		
1963 a 1964	94,8	5,2	95,3	4,7	97,0	3,0	100,0	0,1	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	99,0	1,0		
1964 a 1965	96,1	3,9	97,8	2,2	98,2	1,8	95,8	4,2	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0		
1965 a 1966	98,0	2,0	98,7	1,3	100,0	0,1	97,3	2,7	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	98,5	1,5	100,0	0,0	82,6	17,4
1966 a 1967	93,9	6,1	78,8	21,2	79,3	20,7	97,2	2,8																

CUADRO VII

P. californiensis. Porcentaje de tallas "grandes" y "chicas" en desembarques de Guaymas, asumiendo t_ρ en 50 colas/libra

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio.		Julio		Agosto	
	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.
1962 a 1963	75,9	24,1	96,1	3,9	90,8	9,2	95,7	4,2	95,9	4,1	91,8	8,2	91,1	8,8	95,0	4,9	89,1	10,9	89,9	10,1	96,7	3,3		
1963 a 1964	92,6	7,4	85,1	14,9	88,4	11,6	96,6	3,4	99,1	0,9	98,2	1,8	96,6	3,4	94,6	5,4	90,8	9,3	84,7	15,2	82,4	17,6		
1964 a 1965	84,1	15,9	87,5	12,5	90,0	10,0	89,1	11,0	90,1	9,9	85,4	14,6	82,7	17,3	82,3	7,7	80,9	19,0	77,3	22,7	83,0	16,9		
1965 a 1966	75,5	24,5	85,3	14,7	91,1	8,9	92,3	7,7	94,4	5,6	94,7	5,3	96,3	3,7	97,3	2,7	88,6	11,4	73,5	26,5	78,2	21,8	81,3	18,7
1966 a 1967	70,0	30,1	69,0	31,0	73,6	26,4																		

G = Camarón grande: 50 camarones por libra o menos

Ch = Camarón chico: 51 camarones por libra o más

CUADRO VIII

P. stylirostris. Porcentajes de tallas "grandes" y "chicas" en desembarques de Guaymas, asumiendo t_ρ en 70 colas/libra

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio		Julio		Agosto	
	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.
1962 a 1963	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0 0		
1963 a 1964	94,6	5,4	94,5	5,5	98,8	1,2	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	99,3	0,7		
1964 a 1965	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0				
1965 a 1966	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	99,5	0,5	100,0	0,0	77,3	22,7
1966 a 1967	100,0	0,0	100,0	0,0	99,6	0,4	100,0	0,0																

CUADRO IX

P. californiensis. Porcentaje de tallas "grandes" y "chicas" en desembarques de Guaymas, asumiendo t_ρ en 70 colas/libra

	Sept.		Oct.		Nov.		Dic.		Enero		Febrero		Marzo		Abril		Mayo		Junio		Julio		Agosto	
	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.	G.	Ch.
1962 a 1963	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	99,4	0,6	98,9	1,1	97,6	2,4	100,0	0,0				
1963 a 1964	100,0	0,0	100,0	0,0	99,5	0,5	100,0	0,0	100,0	0,0	100,0	0,0	100,0	0,0	99,9	0,1	98,5	1,5	96,8	3,2	95,5	4,5		
1964 a 1965	99,1	0,9	99,7	0,3	99,6	0,4	99,7	0,3	99,7	0,3	98,2	1,8	96,8	3,2	96,7	3,3	96,8	3,2	94,1	5,9	98,4	1,6		
1965 a 1966	99,5	0,5	99,8	0,2	100,0	0,0	99,9	0,1	100,0	0,0	100,0	0,0	100,0	0,0	99,9	0,1	97,3	2,7	93,2	6,8	94,9	5,1	95,8	4,2
1966 a 1967	99,3	0,7	96,3	3,7	97,0	3,0	99,3	0,7																

G = Camarón grande: 70 camarones por libra o menos

Ch = Camarón chico: 71 camarones por libra o más

definitivas. Por lo tanto, en la práctica, el crecimiento del camarón café en los primeros viajes está asegurado por la pesca preferencial que se hace sobre el camarón azul en profundidades menores. Así, pues, queda la disyuntiva de si se debe buscar protección al crecimiento del camarón café, nacido en primavera y que ya está desarrollado pero aún de tallas "chicas" a fines de junio y principios de julio, así como a poblaciones en crecimiento en los primeros viajes de la temporada.

De acuerdo con lo anterior, se recomienda la continuación de los muestreos actuales y el comienzo de estudios formales sobre mortalidad y reclutamiento, con el fin de llegar a conclusiones viables en cuanto a si las vedas actuales en el Pacífico mexicano se justifican, o si debe haber un aumento o una disminución en las referidas restricciones, tomando en cuenta las grandes diferencias entre las condiciones reinantes en aguas protegidas y en mar abierto.

En el caso de que la experiencia de Kutkuhn (1962) resultase aplicable en todas sus partes a las circunstancias reinantes en el Pacífico mexicano, no sería posible justificar biológicamente la veda actual de dos meses en alta mar, y mucho menos la extensión de ésta a tres meses como se propone con alguna insistencia.

Es necesario tener en cuenta, sin embargo, que el citado trabajo se refiere específicamente a otra especie (*P. duorarum*) y a otras aguas (el Golfo de México), y que además la estructura de precios es muy distinta tratándose del régimen cooperativista de México comparado con la venta directa en el mercado de los Estados Unidos de América.

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CONTRIBUCION AL CONOCIMIENTO DE LOS PALEMONIDOS DE MEXICO: III PALEMONIDOS DEL GOLFO DE CALIFORNIA, CON NOTAS SOBRE LA BIOLOGIA DE *Macrobrachium americanum* BATE

por

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Extracto

El presente trabajo se ocupa de la distribución de 16 especies de langostinos de la familia Palemonidae en el Golfo de California y en los ríos que en él desembocan. Las investigaciones enfocan especialmente las características sexuales secundarias de *Macrobrachium americanum* así como la embriología de esta especie, cuyo cultivo artificial ofrece buenas perspectivas.

THE PALAEMONID SHRIMPS OF MEXICO: III PALAEMONIDAE OF THE GULF OF CALIFORNIA, WITH NOTES ON THE BIOLOGY OF *Macrobrachium americanum* BATE

Abstract

The distribution is given for 16 species of palaemonid shrimp in the Gulf of California and rivers flowing into it, with special attention to the secondary sexual characteristics and embriology of *Macrobrachium americanum*, the artificial culture of which offers great promise.

LES LANGOUSTINES DE MEXIQUE: III PALAEMONIDAE DU GOLF DE CALIFORNIA, AVEC NOTES SUR LA BIOLOGIE DE *Macrobrachium americanum* BATE

Résumé

La distribution de 16 espèces de langoustines de la famille Palaemonidae au Golf de California et dans les fleuves tributaires est décrite. Les investigations sont dirigées particulièrement sur les caractéristiques sexuelles secondaires de *Macrobrachium americanum* et aussi sur l'embriologie de cette espèce, dont la culture artificielle promet des bonnes perspectives.

1 INTRODUCCION

El presente trabajo constituye el resultado del análisis de las colectas, que para el estudio ecológico de este grupo se han iniciado en ambas costas del Golfo de California, así como en los ríos y afluentes que en él desembocan. Dichas colectas se han efectuado durante los años 1964, 1965 y 1966; los ejemplares han sido preservados en alcohol al 70 por ciento y se encuentran en el laboratorio de la Estación de Biología Pesquera de Guaymas, Sonora.

Especial interes tiene en la zona el langostino Macrobrachium americanum Bate por lo que se ha emprendido su estudio enfocando principalmente los caracteres de dimorfismo sexual, reproducción y las transformaciones embriológicas que sufren los huevecillos desde la puesta hasta la eclosión, en la creencia de que será de utilidad el iniciar su cultivo, el cual podría constituir una importante industria pesquera en algunos estados del oeste mexicano.

2 DESCRIPCION DEL AREA DE ESTUDIO

El Golfo de California está constituido esencialmente por una gran fosa tectónica dentro de la cual se han formado fallas más recientes y fosas más o menos profundas. Gran parte de la costa oeste está bordeada de altos acantilados, con abundancia de playas rocosas; en cambio la costa este está constituida por amplias playas arenosas y algunas zonas lodosas, como el área del delta del Colorado, a lo largo de la costa a la altura de Hermosillo y las encontradas al sur del Río Yaqui. Las lagunas costeras son pocas en esta región por la escasa frecuencia de lluvias, pero son más numerosas en el sur de Mazatlán donde la lluvia llega a alcanzar hasta 50 pulgadas anuales. A todo lo largo de ambas costas existe gran número de bahías semicerradas y algunas de ellas con condiciones hipersalinas, como las que se encuentran al norte de Guaymas.

La plataforma continental en los litorales de Sonora y Sinaloa es en general estrecha, poco profunda y recubierta por depósitos procedentes de la Sierra Madre Occidental, desembocando en ella diez grandes ríos: cuatro pertenecientes a Sonora (Río Colorado, Río Concepción, Río Yaqui y Río Mayo) y seis a Sinaloa (Río Sinaloa, Río Fuerte, Río Humaya, Río San Lorenzo, Río Piaxtla y Río Presidio). Al contrario, en los márgenes occidentales del Golfo y a muy escasa distancia de la costa, hay aguas muy profundas y los depósitos de agua dulce que en este litoral desembocan, son muy escasos y de poca importancia (Parker, 1964) (Fig. 1).

3 DISTRIBUCION DE LAS ESPECIES COLECTADAS

Se colectaron 16 especies de palemónidos a lo largo de ambas costas del Golfo de California, de las cuales las diez primeras (Cuadro 1 y Fig. 2) corresponden a la subfamilia Pontoniinae que se dintingue por la ausencia de pleurobranquias a partir del tercer maxilípedo y tres pares de espinas en el margen posterior del telson.

De las seis especies de la subfamilia Palaemoninae, las tres del género Macrobrachium presentan posibilidades de cultivo, especialmente M. americanum que tiene amplia aceptación comercial y cuyas características se describen a continuación.

4 Macrobrachium americanum BATE

De los langostinos encontrados en el Pacífico, los ejemplares de esta especie son los de mayor tamaño. Es por lo tanto la especie de mayor importancia económica. Sin embargo, en los estados de Sonora y Sinaloa es muy poco apreciada, pues en el primero no se ve nunca en el mercado local y en el segundo se explota en baja escala, en comparación con otros estados de la República.

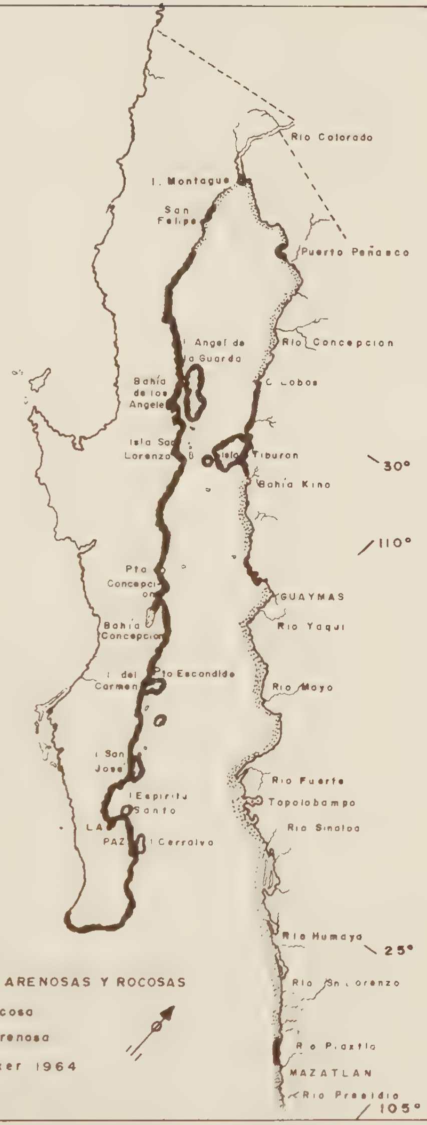

Fig. 1

DISTRIBUCION DE AREAS ARENOSAS Y ROCOSAS

Tomado de Parker 1964

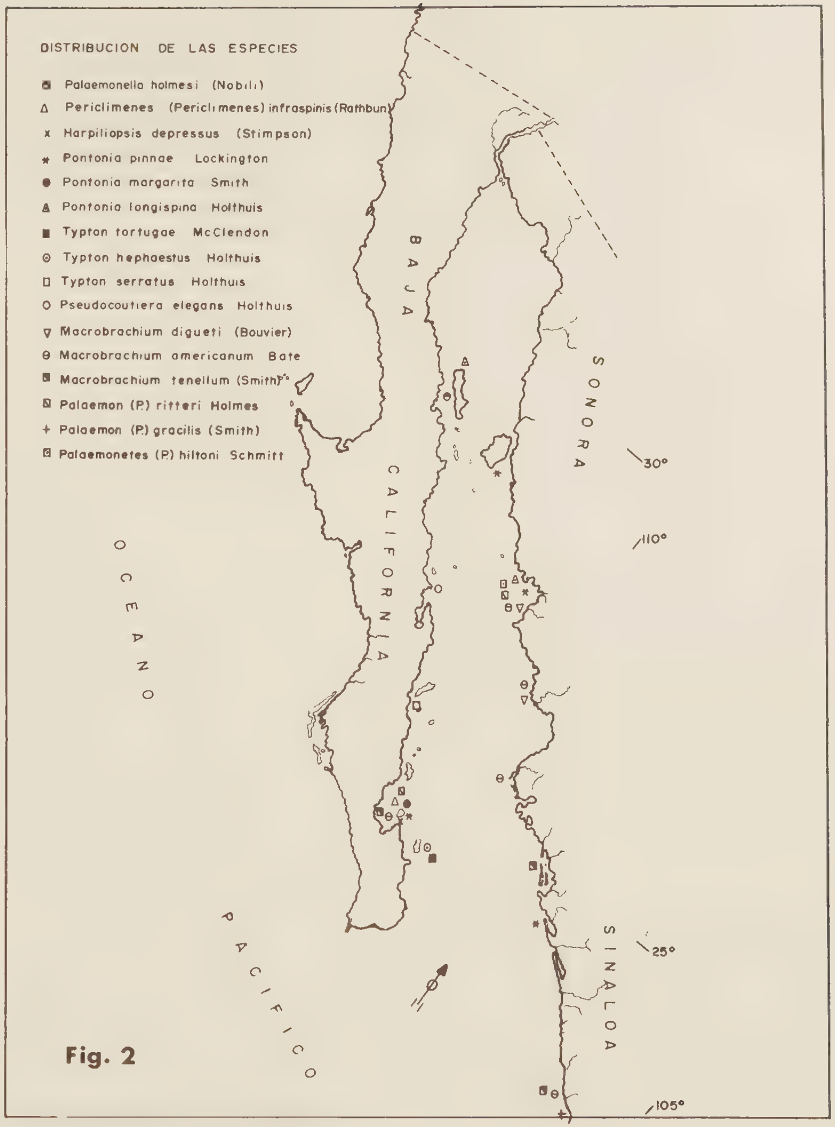
DISTRIBUCION DE LAS ESPECIES
▣ Palaemonella holmesi (Nobili)
△ Periclimenes (Periclimenes) infraspinis (Rathbun)
x Harpiliopsis depressus (Stimpson)
* Pontonia pinnae Lockington
● Pontonia margarita Smith
▲ Pontonia longispina Holthuis
■ Typton tortugae McClendon
⊙ Typton hephaestus Holthuis
□ Typton serratus Holthuis
○ Pseudocoutiera elegans Holthuis
▽ Macrobrachium digueti (Bouvier)
θ Macrobrachium americanum Bate
◨ Macrobrachium tenellum (Smith)
⊠ Palaemon (P.) ritteri Holmes
+ Palaemon (P.) gracilis (Smith)
⊡ Palaemonetes (P.) hiltoni Schmitt
BAJA
CALIFORNIA
SONORA
30°
110°
OCEANO
PACIFICO
SINALOA
25°
105°

Fig. 2

CUADRO I

Distribución de los Palemónidos en el Golfo de California

Especie	Localidad de Captura	Fecha de Captura	No. de Ejemplares Colectados	Longitud	Hábitat	Notas
Palaemonella holmesi (Nobili)	Bahía Falsa, Baja Calif. Isla Espíritu Santo, B. C., Isla Angel de la Guarda, B. C.	30-I-66 30-I-66 25-I-66	10 machos 7 hembras	10 a 25 mm	Aguas costeras poco profundas, viven asociados con algas y corales.	
Periclimenes (*Periclimenes*) *infraspinis* (Rathbun)	Isla Espíritu Santo, B. C.	30-I-66	3 machos	15 a 20 mm	Aguas costeras poco profundas, con fondos arenosos o rocosos.	
Harpiliopsis depresus (Stimpson)	Frente a Isla La Gaviota, B. C.	19-XII-64	2 machos 1 hembra	20 a 25 mm	Sobre fondos rocosos, en la zona de mareas	
Pontonia pinnae Lockington	El Mogote, B. C. Bahía Falsa, B. C. Canal de La Paz, B.C. Isla Tiburón, Son. Bahía de Guaymas, Son. Bahía de Altata, Sin.	18-XII-64 19-XII-64 30-I-66 17-IX-65 26-I-66 17-VIII-64	23 machos 17 hembras	10 a 60 mm	Comensales en la cavidad paleal de *Pinna rugosa* - - Sowerby	Es común encontrar viviendo una o más parejas dentro de una "hacha" y ocasionalmente dentro de la madre -- perla.
Pontonia margarita Smith	Bahía de La Paz, B. C.	19-XII-64	6 machos 6 hembras	15 a 30 mm	Comensales en la cavidad paleal de *Pinctada mazatlánica* (Hanley)	Se encuentran por parejas en cada molusco. Es interesante hacer un estudio más amplio para determinar la influencia que pueda o no tener en la -- formación de perlas.
Pontonia longispina Holthuis	Punta La Paz en la Bahía de Guaymas, Son.	25-VI-65	1 macho	17 mm	Aguas someras, fondos rocosos	
Typton tortugae Mc Clendon	24° 12' N 109° 55' W			11 a 15 mm	Aguas someras, fondos rocosos	Reporte del Holthuis
Typton Hephaestus Holthuis	24° 12' N 109° 55' W			10,5 a 11 mm	Aguas someras, fondos rocosos	Reporte del Holthuis
Typton serratus Holthuis	Puerto Escondido, B.C.			10 mm	Vive sobre esponjas	Reporte del Holthuis
Pseudocoutierea elegans Holthuis	Punta Concepción, B. C.	5-V-65	1 macho 3 hembras	10 a 15 mm	Sobre fondos arenosos zona de mareas	
Macrobrachium digueti (Bouvier)	Río Yaqui, Son. Río Mayo, Son.	18-IV-65 25-VII-65 20-IV-65 30-VII-65	11 machos 7 hembras	45 a 80 mm	Canales de riego, aguas dulces poco profundas y claras	Presenta posibilidades de cultivo
Macrobrachium americanum Bate	Río Yaqui, Son. Río Mayo, Son. Río Fuerte, Sin. Río Presidio, Sin.	18-IV-65 25-VII-65 20-IV-65 30-VII-65 15-V-64 12-XII-64	8 machos 25 hembras	57 a 230 mm	Canales de riego, ríos poco profundos con aguas claras	Tiene las mejores posibilidades de cultivo y es una especie de mayor demanda
Macrobrachium tenellum (Smith)	La Paz, B. C. Los Cocos, Sin. Río Presidio, Sin.	30-I-66 7-III-65 12-XII-64	21 machos 9 hembras	20 a 134 mm	Aguas dulces poco profundas claras. Comúnmente en esteros y lagunas costeras	Presenta posibilidades de cultivo, comercialmente tienen buena aceptación
Palaemon (*Palaemon*) *ritteri* Holmes	Puerto Balandros, B. C. Bahía Los Angeles, B.C. Punta Diablo, B. C. Bahía de Guaymas, Son.	15-II-65 20-IX-65 17-XII-64 25-VI-66	45 machos 58 hembras	20 a 40 mm	Aguas someras, pozas de mareas zona de mareas fondos arenosos	
Palaemon (Palaemon) *gracilis* (Smith)	Agua Verde, Sin.	2-IX-64	4 machos 1 hembra	35 a 64 mm	Aguas salobres poco profundas	Es oriundo de Nicaragua y sur de Panamá, ampliándose su área de distribución 1310 millas marinas
Palaemonetes (*Palaemonetes*) *hiltoni* Schmitt	Bahía de Guaymas, Son.	2-VII-66	5 machos	20 a 23 mm	Aguas poco profundas	

M. americanum es uno de los langostinos más apreciados de este género debido a que alcanza mayor tamaño en estado adulto, variando en los machos de 57 a 230 mm de longitud y en las hembras ovígeras entre 57 y 180 mm. Son langostinos de cefalotórax y abdomen robustos, el primero ligeramente menor de un tercio de la longitud total, con el segundo par de pereiópodos muy desarrollados (Fig. 3).

4.1 Dimorfismo sexual

La diferenciación sexual externa es muy notable, ya que además del tamaño siempre mayor del macho, éste se distingue fácilmente por el mayor tamaño que alcanza su segundo par de pereiópodos. También el segundo par de pleópodos varía, ya que en la hembra sólo se presenta el apéndice interno como pieza anexa situada sobre el basipodito, siendo un segmento pequeño ligeramente menor que la mitad del endopodito cuyo extremo distal presenta una zona plana cubierta de pequeñísimas espínulas. En el macho se presenta además del apéndice interno, el apéndice masculino; el primero tiene forma semejante al endopodito con el borde y superficie externos cubiertos de sedas y es además un poco más grande que la mitad de éste. El apéndice masculino está situado en el basipodito del pleópodo, sobre el inicio del endopodito y borde interno del apéndice interno. Es un segmento pequeño que mide alrededor de un tercio de la longitud del endopodito. Su extremo distal está aplanado y cubierto por pequeñísimas espínulas, más concentradas en el borde externo que en la parte central. Las espínulas tienen forma de ganchitos.

Esta especie es dulceacuícola, aunque al igual que otros miembros del género se pueden encontrar individuos juveniles en aguas salobres, ya que resisten más la alta salinidad que las formas maduras.

Hemos observado que los movimientos migratorios parecen estar relacionados con la salinidad óptima requerida por la hembra para el desarrollo de sus huevos.

4.2 Alimento

Hemos observado en ejemplares cautivos que son omnívoros, aunque prefieren principalmente alimentarse de formas animales, como pequeñas larvas de otros crustáceos, peces de los llamados forrajeros, organismos en descomposición y carne seca de res, conocida localmente como machaca.

4.3 Reproducción

Como se dijo antes, se consideran adultos los ejemplares que miden más de 57 mm de longitud total; la copulación se efectúa vientre con vientre, depositando el macho los espermatozoides dentro del receptáculo seminal de la hembra. Esto se realiza, por lo general, después de una muda reciente.

La época de reproducción tiene lugar entre los meses de junio y septiembre y tal vez se prolongue hasta octubre; las hembras llevan los huevos adheridos por medio de secreciones de las glándulas de cemento localizadas en la base de los pleópodos y urópodos, a las formaciones pilosas de los primeros, que en esta época se encuentran muy desarrolladas. El número de los huevos oscila entre 200.000 y 500.000 según el tamaño de la hembra y miden alrededor de 0,44 a 0,67 mm.

4.4 Desarrollo

Los primeros estadios larvales ocurren dentro del huevo, ya que es característica de los carídeos suprimir las formas larvales libres.

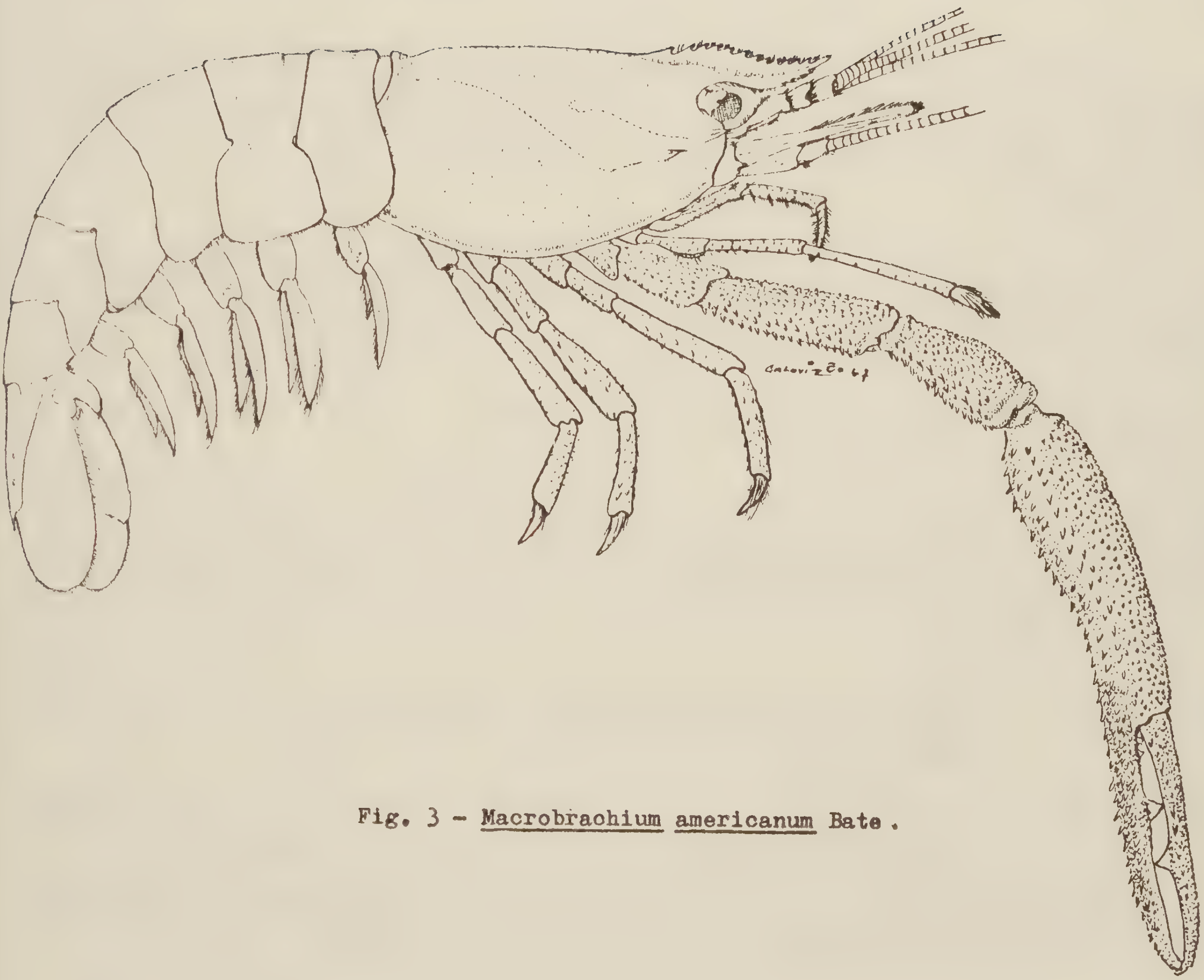

Fig. 3 - Macrobrachium americanum Bate .

El huevecillo recientemente fecundado presenta un aspecto homogéneo, debido a que el vitelo se encuentra uniformemente distribuido, formándose posteriormente una zona más oscura en el polo anterior que representa la zona embriológicamente activa. Más tarde se diferencian cinco zonas de las cuales las dos anteriores probablemente corresponden a los lóbulos cefálicos, las dos medias a las placas torácico-abdominales y la posterior a la placa endodérmica. Posteriormente se disciernen con claridad las manchas oculares y el esbozo de los somitos del cuerpo, los que a medida que pasa el tiempo se van haciendo más aparentes, observándose posteriormente un somito para cada apéndice.

Poco antes de la eclosión, el individuo presenta un aspecto semejante al adulto, solo que sus branquias son externas y el telson no está del todo constituido. Al eclosionar, el pequeño especimen alcanza alrededor de 1 cm de longitud total y únicamente se diferencia del adulto por tener desproporcionado el sexto segmento del abdomen.

En condiciones de laboratorio no muy apropiadas, se lograron obtener 54 juveniles que en 45 días llegaron a medir 38 mm los cuales mudaron de 3 a 6 veces. Alimentados en especial con trocitos de carne seca de res no denotaron canibalismo. Se cree que estos ejemplares podrían fácilmente sobrevivir en estanques o canales de riego, como indican Ling (1967) y Elías (en prensa).

5 CONCLUSION

En la zona estudiada se encontraron distribuidas 16 especies de palemónidos tres de las cuales pertenecientes al género *Macrobrachium* son dulceacuícolas, aunque una de ellas es frecuente en los esteros y lagunas costeras. De las otras, una es estuarina y doce francamente marinas; de estas últimas la mayoría son libres nadadoras y otras comensales.

Para la especie *Palaemon* (*Palaemon*) *gracilis* (Smith) se amplía su área conocida de distribución en 2.400 km.

El interés que ha despertado el estudio de los langostinos de agua dulce se debe principalmente a las posibilidades de su cultivo y al alto precio que alcanzan en el mercado; de ahí que se realizara el presente estudio monográfico de los palemónidos del Golfo de California dedicando atención especial a la especie *M. americanum* que por su tamaño es la de mayor aceptación comercial.

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THE DETERMINATION OF SOME STAGES OF THE MOLTING CYCLE OF *Penaeus duorarum*, BY MICROSCOPIC EXAMINATION OF THE SETAE OF THE ENDOPODITES OF PLEOPODS

by

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Abstract

Microscopic examination of the setae of the endopodites of the pleopods gives a clear indication of the molting stages of *P. duorarum* up to the intermolt stage. On the basis of the observed molts, the duration of postmolt stages A to C represents 19 percent of the total cycle, which lasted for 16 days in animals with an average carapace length of 25.4 mm.

DETERMINATION DE CERTAINS STADES DU CYCLE DE LA MUE DE *Penaeus duorarum*, PAR L'EXAMEN AU MICROSCOPE DES BROSSES DES ENDOPODITES DES PLEOPODS

Résumé

L'examen au microscope des brosses des endopodites des pléopodes révèle nettement à quel stade du cycle de la mue se trouve la crevette *P. duorarum*, jusqu'au stade d'intermue. Sur la base des mues observées, la durée des postmues A a C represénte 19 pour cent du cycle total, qui était en l'occurrence de 16 jours pour des animaux mesurant en moyenne 25,4 mm de longuer de carapace.

E/14

DETERMINACION DE ALGUNOS ESTADIOS DEL CICLO DE MUDA DEL CAMARON ROSADO, *Penaeus duorarum*, PRO EXAMEN MICROSCOPICO DE LAS SEDAS DE LOS ENDOPODITOS DE LOS PLEOPODS

Extracto

El examen microscópico de las sedas de los endopoditos de los pleópodos proporciona una clara indicación de los estadios de muda de *P. duorarum*, hasta la etapa de intermuda. Tomando como base las mudas observadas, la duración de los estadios de postmuda A a C representa el 19 por ciento del ciclo total, el cual duró 16 días en animales con una longitud de carapacho de 25,4 mm.

1 INTRODUCTION

The molting cycle of Penaeus duorarum Burkenroad has not been described. In a recent review, Passano (1960) states that few aspects of crustacean physiology are as important as molting.

Growth of Crustacea is directly related to the molt cycle, since size increases cannot occur while the animal is encased in its shell.

Important changes in food reserves and metabolism accompany the different stages of the molt cycle. The outgrowth of this study was to be a determination of storage materials utilized by starved shrimp, and it was anticipated that changes in the relative amounts of these products might be obscured by normal variation during the molting cycle. It therefore became obvious that it was essential first to describe the molt cycle of P. duorarum in sufficient detail to identify the specific stage of the cycle in individual animals.

In 1939, Drach devised a scheme to describe the molting cycle of decapod crustacea. This classification has superseded all others. In natantians the cycle is described as follows:

TABLE I

Natantian intermolt stages
(from Passano, 1960, after Drach, 1939)

Stage	Duration (%)	Characteristics
A	2.5	
A_1		Very soft exoskeleton; matrix fills new spines
A_2		Branchiostegites flexible, bend under slight pressure; spine matrix retracts towards middle of spine
B	16.5	
B_1		Branchiostegites semi-rigid; exoskeleton of a parchment-like consistency; conical base of spines absent
B_2		Conical base of spines partially formed
C	21.0	Exoskeleton fully formed; conical base of spines complete. (The intermolt period)
D	60.0	
D_0		Hormonal activation; the epithelium then separates from the old cuticle
D_1	21.0	New spine formation begins; initial retraction of nerve fiber from the cavity of the old spine
D_1''	14.0	Secretion of new spines begins
D_1'''	6.5	Morphological details of new spines become visible

TABLE I.-(Contd.)

Stage	Duration (%)	Characteristics
D_2		Formation of pre-exuvial layers of new skeleton
D_3	17.0	Resorption of old exoskeleton
D_4	1.0	Old exoskeleton splits in preparation for ecdysis
E	0.5	Ecydsis

Scheer (1960) studied several aspects of the intermolt cycle in natantians using three caridean shrimp, Palaemon xiphias (as Leander), Processa acutirostris, and P. edulis. He described four stages in the intermolt cycle, A, B, C, and D, these stages being further subdivided (Table II).

TABLE II

Characteristics of intermolt cycle stages in natantians (from Scheer, 1960)

Stage	Characteristics
A (early postmolt)	Integument soft, parchment-like, internal cones of setae of uropods absent
B (late postmolt)	Integument firm but yielding to pressure, internal cones of setae incomplete
C_a (early intermolt)	Integument firm to hard, internal cones of setae nearing completion
C_b (late intermolt)	Integument hard, internal cones of setae complete, slight separation of epidermis from cuticle between setae
D_o (beginning premolt)	New setae present at base of old, epidermis clearly separated from cuticle, bases of new setae at the outer surface of the epidermis
D_1 (early premolt)	New setae in course of development
D_1'	New setae extending partly into old, their bases beginning to invaginate below the surface of the epidermis
D_1''	New setae extending well into old, the bases invaginated into the epidermis for approximately 1/4 the length of the setae

TABLE II-(Contd.)

Stage	Characteristics
D_1'''	Bases of new setae invaginated for approximately 1/2 the length of the setae
D_2 (middle premolt)	Epidermis with a clearly developed cuticular layer
D_3 (late premolt)	Epidermis with a chitinous pigmented cuticular layer
D_4 (final premolt)	The old carapace separates readily from the new cuticle on slight pressure

Scheer's work is essentially a modification of Drach's criteria, since the changes introduced were suggested by Drach personally (Scheer, 1960). This work is used as the foundation to determine the stages of the molting cycle in P. duorarum.

2 MATERIALS AND METHODS

Live shrimp were obtained from a local bait fisherman. The animals were captured in the southern part of Biscayne Bay. A preliminary study conducted by Costello (1963), has shown that the shrimp catches in this area comprise two species of penaeid shrimp, P. duorarum and P. brasiliensis Latreille. The relative numbers of these species change during the seasons of the year.

Since a small percentage of the sample could be expected to be represented by P. brasiliensis, it was important to determine the species of each shrimp in the sample. The criteria described by Voss (1955) were used. Individuals were also compared with unpublished drawings by Boschi. Species identification was uncertain in the smaller males, therefore only the females in the samples were used.

At the beginning of the experiments the shrimp were transferred to 10 gallon (45 l) aquaria. Each aquarium was equipped with a sub-sand filter and was subdivided by six fiberglass-plastic partitions. Each compartment contained one shrimp. The shrimp were examined daily to identify those which had molted overnight. Individual records were kept of the molts.

The endopodites of pleopods were removed, mounted in sea water on microscope slides and the setae and spines were photographed under the low power (100X) of a compound microscope. The photographs were later used to determine the stage of the molting cycle, according to the criteria employed by Scheer (1960) and observations of molts in the aquaria.

3 RESULTS

A comparison of the molting histories of individuals and the microscopic observation of their appendages revealed that changes in the molting stage could be detected by observing the internal structure of the setae on the pleopods (Figs. 1, 2, 3 and 4). During the early part of what is here called the postmolt period, each seta is filled with a translucent cellular matrix. Near the end of the postmolt stage, this material remains only at the basal end of the seta, close to a cone-shaped structure that begins to form at this time. The intermolt period begins when the translucent material has disappeared from the seta and the cone has become complete. The setae of pleopods removed from animals the day before the night of the molt showed no structural evidence of premolt changes.

The observations on the molts of the experimental animals are summarized in Table III. Forty four percent of the animals molted during the first seven days of captivity, and this, coupled with observations by Ewald (personal communication) on P. duorarum and Zein-Eldin (1961) on P. aztecus, suggests that the molt cycle might have a duration of 16 days. The postmolt period was about three days, or 19 percent of the suggested 16-day cycle.

TABLE III

Percentage of total population molting

Number of Days	Number of Animals	Number Molted	Percent Molted
0	30	0	0
1	30	4	13
2	23	2	9
3	17	1	6
4	17	1	6
5	10	0	0
6	19	0	0
7	9	1	11

4 DISCUSSION

4.1 Molting cycle

In his recent review, Passano (1960) states, "Few aspects of crustacean physiology are as important as molting". In natantians this process is regulated by the central nervous system through specialized neurosecretory hormones. Welsh (1961) points out that the action of neurons cannot be explained solely in electrical terms, but that their most characteristic feature is the ability to synthetize and release chemical agents which act in a hormone-like manner. Some of these agents, such as acetylcholine, act at close range at synapses and neuromuscular junctions; others, such as the molting hormones of Crustacea, enter the blood and produce general systemic effects.

The sinus gland system in crustaceans consists of neurosecretory cells in various ganglia which send their axons to a common release center in each eyestalk, called the sinus gland. The nerve endings are arranged in such a way that released materials traverse a thin membrane before they contact the haemolymph. Of particular interest here is the group of secretory nerve-cell bodies that comprise the papilla X-organ in natantians. The neurosecretory molt-inhibiting hormone, is synthesized in the cell body and migrates via the axoplasm to the axon terminals where it is stored in the form of discrete granules. The hormone is then released through the sinus gland into the blood stream. Welsh favors the theory of cycles of production and nonproduction of the molt-inhibiting hormone. The nonproduction cycle is triggered by external and internal factors. The external factors are light, temperature, and seclusion. Among the internal factors regulating the release of molting hormones are the accumulation of organic reserves and other demands on nutrients. When the X-organ hormone concentration in the blood is reduced, the Y-organ is activated. The Y-organ, a neurohemal organ, liberates a molting hormone, ecdysone.

With the release of the molting hormone, proecdysis is initiated. This initial stage is denominated D_0. It is not characterized by morphological changes. When stage D_1 is reached, the formation of the new exoskeleton begins. This process is evidenced by the formation of new spines within the old ones. As proecdysis continues, resorption of organic and inorganic materials increases, and exoskeleton formation continues. The skeletal alterations coincide with changes in behavior of the animal which soon ceases to feed; this is stage D_2. The tissues suffering major changes during this period of starvation are the integument, the hepatopancreas, and the blood.

Ecdysis, or stage E, is divided into a passive and an active phase. Natantians exuviate late at night. At the beginning of this stage, the blood osmotic pressure rises. When the old gastric lining breaks down, water is swallowed, increasing the hydrostatic pressure in the digestive tract. These two factors combined accelerate the movement of water to the haemolymph, increasing its volume. The animal swells and the carapace ruptures. The active phase begins after the carapace has split, and the animal begins to withdraw from the exuvium. Once the animal has moved out of the old shell, the appendages become turgid.

Water uptake continues during the early part of the postecdysal stages (A_1). Calcification of the exocuticle begins and the new endocuticle begins to form. Tissue growth, measured as increase in dry weight, begins during stage B_2 or C_1, continuing during C_2 and C_3. Protein and DNA show the highest turnover rates during this time (Passano 1960).

4.2 Changes in the integument

At the stage C_4 (end of the intermolt period), the integument consists of five layers (Fig. 5). The epidermis (A), consists of an epithelium composed of closely packed simple subcuboidal cells and associated gland cells, connective tissue, and sensory nerve endings. This layer is the only living part of the integument and secretes the other layer. There is a thin, membranous layer (B), proteinaceous and noncalcified, overlying the epidermis. During proecdysis the membranous layer splits, giving rise to the mucilaginous layer which helps the animal during exuviation. The main portion of the exoskeleton is composed of the endocuticle (C). This layer accounts for 80% of the integument thickness, and is secreted and mineralized after ecdysis during stages A_2 through C_3. The layer is rich in chitin, which comprises 70% of the organic matter, and is low in protein. It is mineralized with calcium salts. The pigmented layer (D), is composed of 40-45% chitin, the rest being protein. This layer is secreted during proecdysal stages D_2 and D_3. The layer is mineralized all at once by salts, shortly after ecdysis. The layer is often strongly pigmented, and together with the chromatophores gives the crustacean its coloration. The very thin epicuticle (E) consists of lipid-impregnated protein and contains no chitin. It is secreted by the epidermis during stage D_1 and may be for the protection of the new exoskeleton from the molting fluid during exuviation.

No marked histological changes are evident during D_o, but during D_1 the epithelium separates from the membranous layer and chitin formation begins. At D_2, full secretory activity is reached. The muscle attachment to the old cuticle breaks down and the muscles become attached to the new skeleton. The pigmented layer is secreted and resorption of mineral and organic matter from the old skeleton begins. Resorption of the organic matter is 23% in Panulirus, 79% in Carcinus (Passano, 1960), and 70% in P. duorarum (Schafer, 1967).

In P. duorarum, no structural changes in the setae of the pleopods could be detected up to the afternoon prior to the night when they molted. This may indicate that the proecdysis portion of the molting cycle is very short in this form. Studies on other natantians, however, suggest that this part of the cycle comprises 59% (D_1 to D_4) (Passano, 1960) to 53% (D_o to D_4) (Scheer, 1960) of the total cycle. The calculated total for the cycle is 16 days. This agrees well with the length of the cycle observed by Ewald (personal communication) in P. duorarum; he reports 12 to 20 days for animals with carapace length of 18 to 22 mm, 14 to 30 days for animals with carapace length of 23 to 27 mm, and 27 to 38 days for animals with carapace length of 28 to 32 mm. Zein-Eldin (1961) observed a molting cycle length of 16 and 15 days for male P. aztecus with initial carapace length of 21.4 and 22.5 mm respectively.

Observations in this study, of the structural changes in the setae of the pleopods, indicate that the postmolt period, from A_1 to the onset of C_1 has a duration of 3 days, or 19% of the total cycle. These observations agree well with the 19% given by Passano (1960) and the 15 to 17% given by Scheer (1960). The early part of this stage is characterized by the presence of a translucent matrix filling the setae (Fig. 1). As the stage

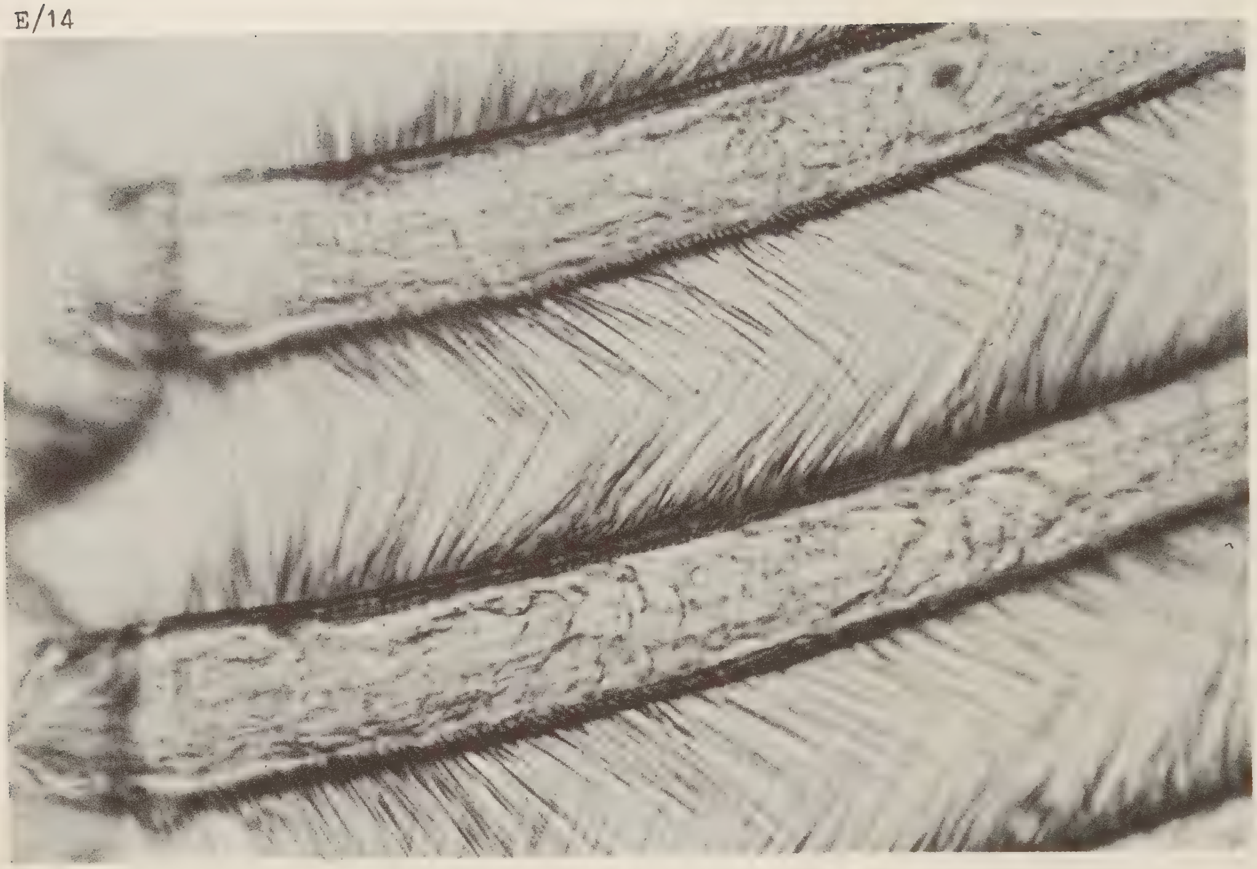

Fig. 1. Setae of endopodite of pleopod, a few hours after molting.

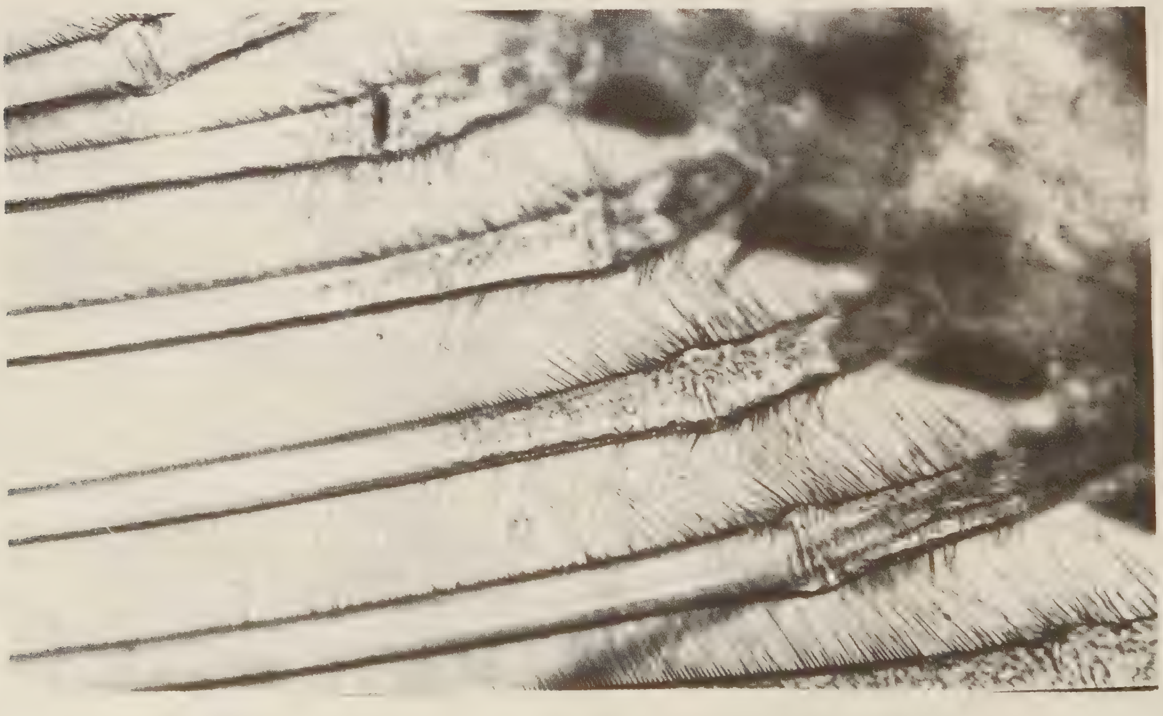

Fig. 2. Setae of endopodite of pleopod, 2 days after molting.

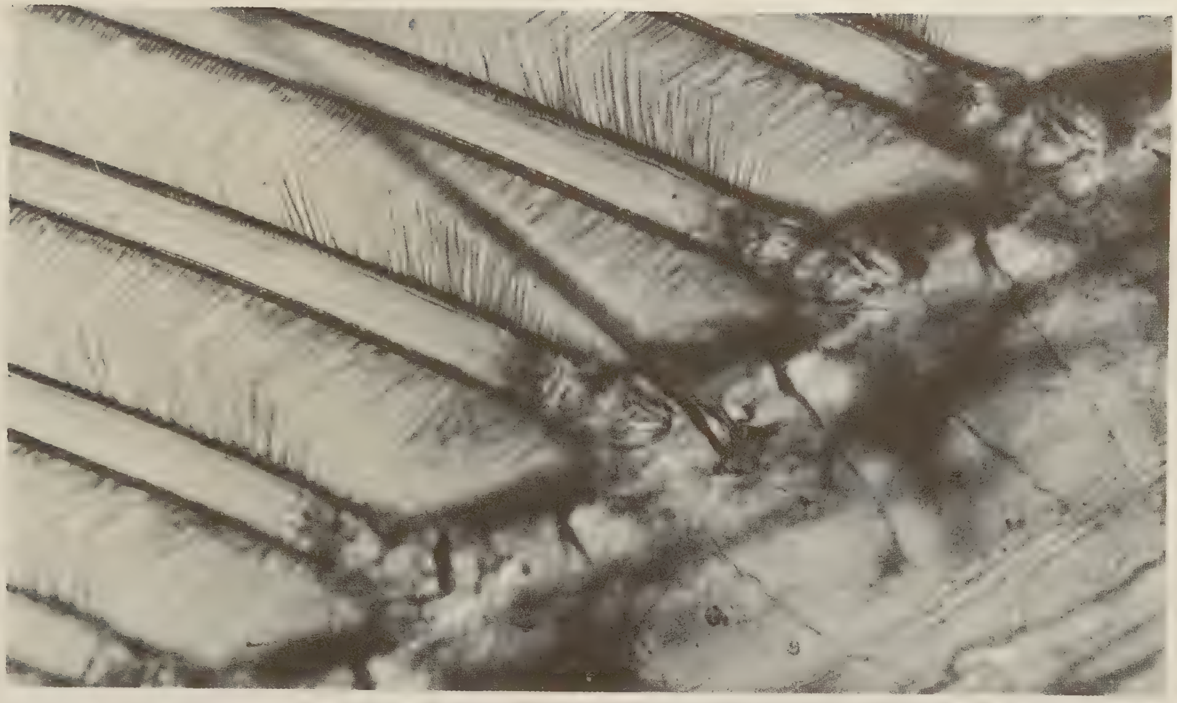

Fig. 3. Setae of endopodite of pleopod, 3 days after molting.

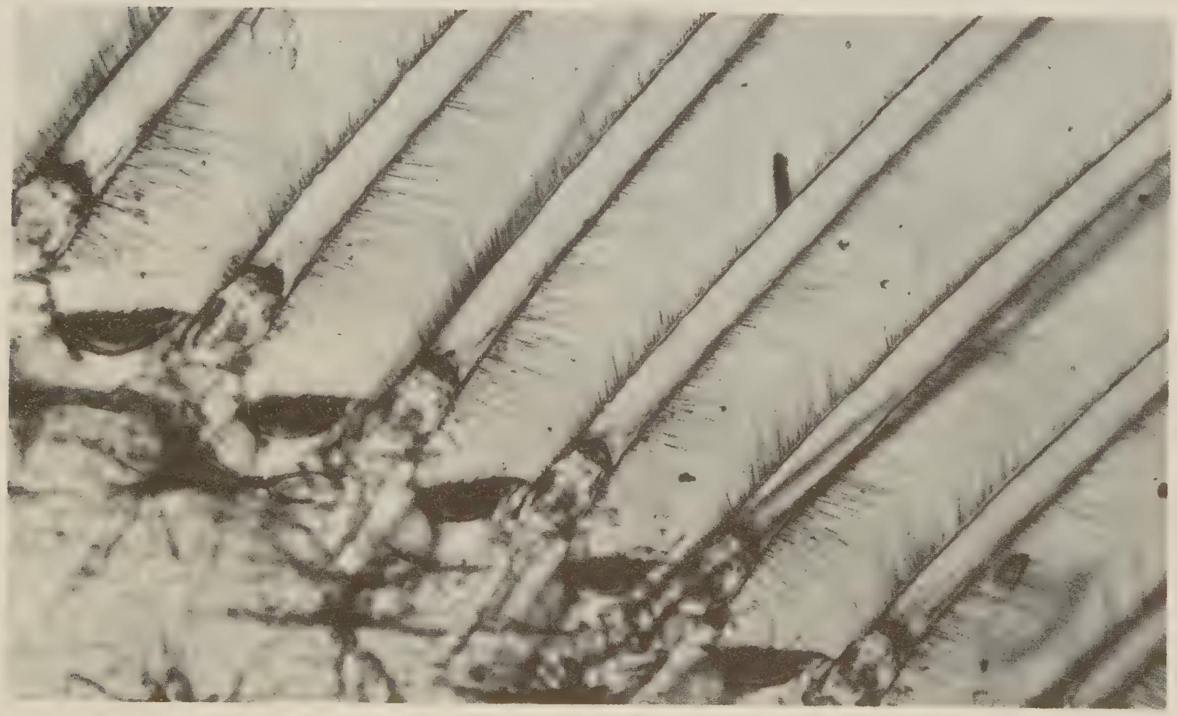

Fig. 4. Setae of endopodite of pleopod, intermolt period.

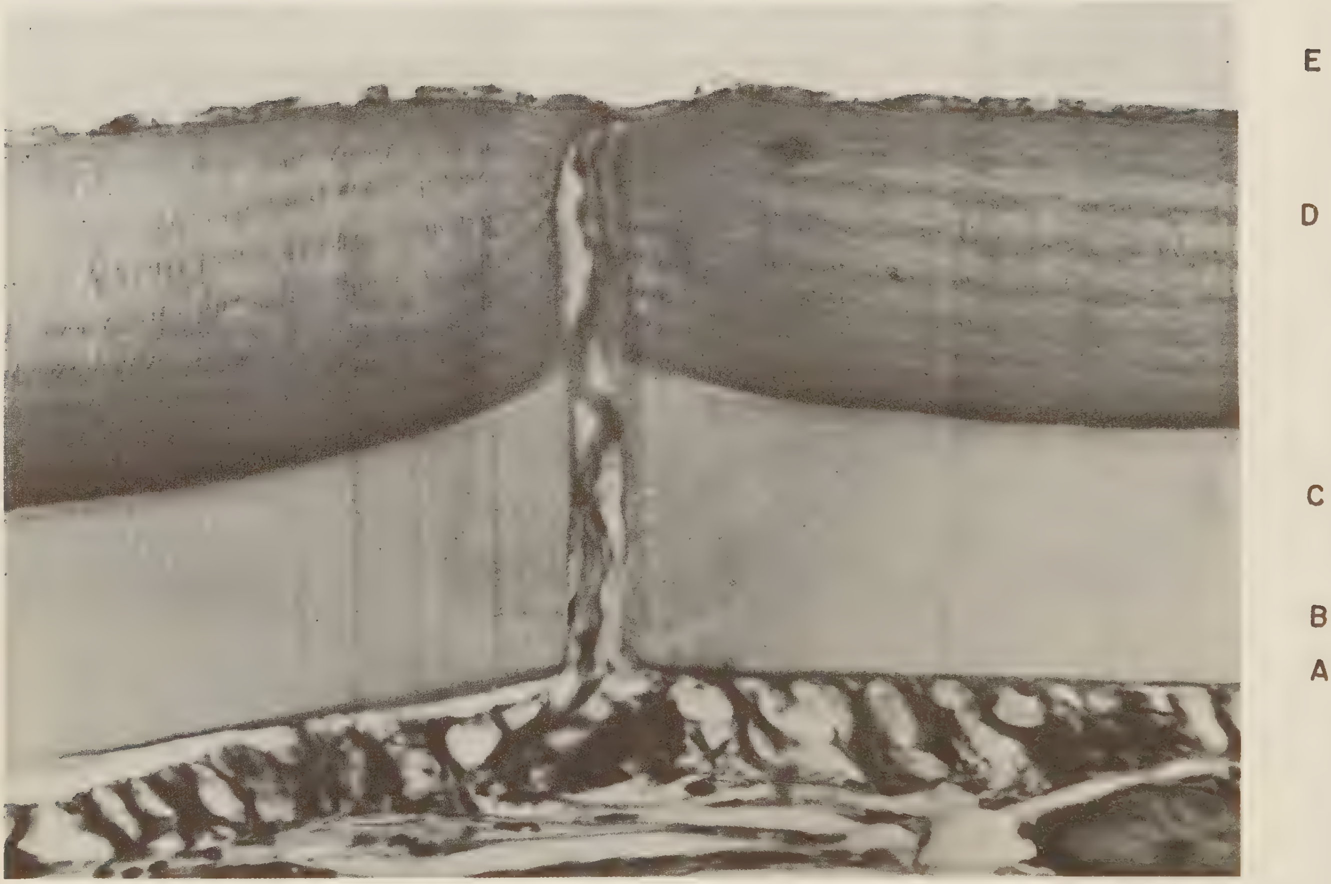

Fig. 5. Integument of P. duorarum. A, epidermis; B, membranous layer; C, endocuticle; D, pigmented layer; E, epicuticle.

advances, the matrix begins to disappear at the distal end and continues to do so until it is evident only at the basal end (Fig. 2). A cone-shaped structure begins to form during late postmolt, stage B_2. By the end of this period, the cone-shape is almost complete and the matrix almost disappeared (Fig. 3). The beginning of the intermolt period C1 is marked by the completion of the cones and the total absence of the matrix from the setae (Fig. 4).

5 SUMMARY

The molting cycle of *P. duorarum* under the conditions encountered appears to last about 16 days. The structural changes within the setae of the endopodites of the pleopods are easily discernible by microscopic examination under 100X magnification during the postmolt period. This stage of the cycle apparently lasts 3 days, or 19 percent of the total cycle.

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STORAGE MATERIALS UTILIZED BY STARVED PINK SHRIMP, Penaeus duorarum BURKENROAD

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Abstract

In order to estimate the utilization of storage materials by pink shrimp during molting, the changes in size of the hepatopancreas at different stages of starvation were studied. Variations in the storage materials in the gland show that starved pink shrimp utilize mainly fat reserves, followed by protein. Total glycogen reserves available would provide only 13 percent of daily energy requirements.

RESERVES UTILISEES PAR LA CREVETTE Penaeus duorarum BURKENROAD PRIVEE DE NOURRITURE

Résumé

A l'objet d'évaluer le degré d'emploi des matériaux de réserve pendant la mue, on a étudié les variations de taille de l'hépatopancréas à diverses périodes de jeûne. Les modifications des réserves de la glande indiquent que les crevettes rosées privées de nourriture utilisent d'abord dans une large mesure les lipides, puis les protéines. Le glycogène total ne fournirait que 13 pour cent du besoin énergétique journalier de P. duorarum.

MATERIALES DE RESERVA UTILIZADOS POR EL CAMARON ROSADO, *Penaeus duorarum* BURKENROAD, EN PERIODOS DE AYUNO

Extracto

Con el fin de estimar el grado de utilización de materiales de reserva durante la muda, se estudiaron las variaciones en el tamaño del hepatopancreas en diversos períodos de ayuno. Las modificaciones en las reservas de la glándula indican que el camarón rosado privado de alimento utiliza principalmente los lípidos y luego las proteínas. El glicógeno total apenas suministraría el 13 por ciento de las necesidades diarias de energía.

1 INTRODUCTION

The pink shrimp, Penaeus duorarum Burkenroad, constitutes an important fishery resource in South Florida and some areas of the Gulf of Mexico and the Caribbean. Although there are fairly complete data on its life history, migrations, larval development, growth rate, and storage qualities, little is known about its physiology. In most cases we can only draw parallels from knowledge about other Crustacea.

The substrates metabolized by the pink shrimp to maintain life have not been investigated before. The present work was undertaken to study what kinds of storage materials these animals utilize while food is denied to them.

It is anticipated that changes in the amounts of storage materials in starved animals may be obscured by changes in these storage products brought about by the normal processes accompanying the molting cycle. To this end it is proposed to utilize data obtained from experimental animals in the intermolt stage only (Schafer, in press), and compare the relative amounts of glycogen, fat, and total nitrogen in the hepatopancreas of animals starved for varying periods of time.

2 MATERIALS AND METHODS

Live shrimp were obtained from a local bait fisherman. The animals were captured in the southern part of Biscayne Bay, Florida. A preliminary study conducted by Costello (1963), has shown that the shrimp catches in this area comprise two species of penaeid shrimp, Penaeus duorarum and P. brasiliensis Latreille, but the first predominates.

One sample of 100 animals was obtained on 3 October 1962, the second sample was obtained on 3 January 1963, and the third sample was obtained on 5 April 1963. Since a small percentage of these samples could be expected to be represented by P. brasiliensis, it was important to determine the species of each shrimp in the sample. The criteria described by Voss (1955) were used. Individuals were also compared with unpublished drawings by Boschi. Species identification was uncertain in the smaller males, therefore only the females in the samples were used.

Since the nutritional status of the animals was not known, they were kept in a cage in running sea water and fed chopped liver regularly for at least two weeks prior to the experiments.

After this feeding condition was standardized as described, the shrimp were sexed and the species identified. Female P. duorarum were placed in partitioned 10-gallon (45 l) aquaria with filtered sea water. The shrimp were starved for different periods of time and then removed. The starvation periods were 1, 2, 4, 6, and 11 days for the first run, 1, 2, 4, and 7 days for the second run and 1, 6, and 12 days for the third run. One sample was taken just prior to the beginning of the experiments to represent zero time. Immediately upon removal from the water the endopodite of one pleopod was excised, mounted in sea water on a glass slide, and examined under the microscope to determine the stage of the molting cycle (Schafer, in press). The shrimps were then vitrified at -72°C immediately after removal from the aquaria by immersion in a dry-ice-ethanol mixture and stored at -20°C in labeled, tightly closed screw cap glass vials until analyzed.

2.1 Analysis

The shrimp were weighed and the hepatopancreas removed by making a cross-sectional cut in the center of the cephalothorax with scissors, followed by a sagittal cut with a scalpel. The hepatopancreas was cut into four pieces which could be easily separated from the frozen tissues of the shrimp. The frozen digestive gland was placed in a tared glass container and weighed. The glands were stored in the deep freeze until analyzed. The glycogen was extracted in trichloracetic acid and precipitated by ethanol.

2.2 Trichloracetic acid extraction

The sample to be extracted was weighed and placed with 25 ml of cold 5 percent trichloracetic acid (TCA) in a Servall high-speed homogenizer vessel. The vessel was immersed in an ice bath and the sample was homogenized for 4 min at 8,000 rev/min. The homogenate was transferred to a polyethylene centrifuge tube and centrifuged at 1150 xG for 15 min. The supernatant was decanted into an Erlenmeyer flask and the precipitate was resuspended in 20 ml 5 percent TCA, and re-homogenized under the same conditions. The homogenate was again centrifuged and the supernatant was combined with the others. The precipitate from the hepatopancreas samples was weighed and used to determine the total nitrogen of the sample. Five volumes of 95 percent ethanol were added with stirring to the combined supernatants in the Erlenmeyer flask. The flasks were placed overnight in the refrigerator. The next day the mixture was transferred after shaking into 250 ml polyethylene centrifuge bottles and centrifuged at 13,200 xG for 25 minutes at 4°C. The supernatant was separated by aspiration and saved. The precipitate containing the ethanol-insoluble carbohydrates was dissolved in 30 ml distilled water and saved for glycogen determinations.

2.3 Glycogen determination

Glycogen was determined by the glucose it released on hydrolysis with concentrated sulfuric acid. Two ml of the TCA water-soluble ethanol-insoluble fraction were placed in a 19 x 150 mm test tube. Then 0.5 ml anthrone solution was pipetted into the test tube, followed by 5 ml concentrated sulfuric acid layered carefully into the tube. The tube was rotated to mix the layers. Careful mixing was continued until the flocculent anthrone precipitate disappeared. After this, complete mixing was insured by inverting the tube once. After the color was developed for at least 10 min, the optical density was measured at 620 mµ against a distilled water blank. Glucose standards containing from 0 to 80 µg of glucose in 2 ml of distilled water were run at the same time. The glycogen content of the unknown was estimated by multiplying the glucose equivalents by 0.9.

2.4 Nitrogen determination

The precipitate from the TCA extractions described earlier were placed on weighed lens tissue squares and dried in an oven at 100°C overnight, then weighed and placed in Kjeldahl flasks with 2 ml concentrated sulfuric acid and one "Hengar" granule. Standard micro Kjeldahl methods were followed.

2.5 Fat determination

The last batch of shrimp was used to determine total fat in the hepatopancreas of the animals. The group was subdivided into three samples, corresponding to starvation for 1, 6, and 12 days respectively. The animals were treated as described earlier. The glands were removed while frozen, weighed and stored in the deep freeze until analyzed. For analysis, the glands were placed one at a time in a mortar with 10 g sodium sulfate per 100 mg sample to absorb the water, and ground. The powder was placed on filter paper in a glass funnel and a measured amount of petroleum ether was poured over the powder to extract the fat. The amount of ether used was 20 ml ether/0.1g sample. The extract was collected in a weighed glass container and the ether was evaporated to dryness. The container was weighed again and the difference represented the total fat in the sample. The percentage of fat in the samples was calculated.

2.6 Treatment of data

(a) The weights of the hepatopancreas, expressed as mg hepatopancreas per body weight, were used as the Y values, against the number of days starved as the X values. The regression line for the values was calcultated and plotted. The slope of the line was tested at the 95 percent confidence level using H_o (slope = 0).

(b) The glycogen content of the hepatopancreas samples was expressed as mg per g of dry tissue. These values were taken as the Y values, against the days of starvation as the X values. The values were treated as before.

(c) The nitrogen content of the hepatopancreas samples, expressed as percent nitrogen, were used as the Y values, against the number of days starved as the X values. The values were treated as in (a).

(d) The fat content of the hepatopancreas samples, expressed as percent fat, were taken as the Y values, against the number of days starved as the X values. The values were treated as before.

(e) The contents are expressed as the mean values ± twice the standard errors of the mean.

3 RESULTS

3.1 Glycogen determinations

The linear regression for the data from intermolt shrimp was calculated and its slope found to be negative and significantly different from zero (Fig. 1). The data variance was 0.402.

3.2 Nitrogen determinations

The percentage of nitrogen present in hepatopancreas samples was determined by standard micro-Kjeldahl techniques (Horwitz, 1955). The linear regressions for the samples were calculated and the slope showed no significant difference from zero at the 95 percent confidence level. Total nitrogen in hepatopancreas samples had a mean value of 6.61 percent ± 0.168, equivalent to an estimated protein content of 41 percent.

3.3 Fat determinations

Total ether-extractable fat content of hepatopancreas was recorded and the linear regression for the data calculated. The slope of the line was negative and differed significantly from zero, indicating that the fat content of the hepatopancreas samples decreases as starvation continues. This decrease is shown in Fig. 2.

3.4 Relative weights of hepatopancreas

The percentage of the total weight represented by the hepatopancreas was recorded and the linear regression for the data calculated. The slope of the line was negative and differed significantly from zero. This suggests that the relative size of the glands decreases with time of starvation. The decrease in size is shown in Fig. 3.

4 DISCUSSION

4.1 General aspects of metabolism

To gain a better understanding of the energy stores available to P. duorarum (Table I), they were calculated for an average 10 g shrimp. All calculations were based on utilization of materials stored in the hepatopancreas. The hepatopancreas decreased in size progessively during starvation. From Fig. 3 it can be estimated that the hepatopancreas of a 10 g animal decreased 23 mg in weight during each day of starvation. This figure, coupled with the protein content of the gland and the daily decreases in glycogen and fat (Fig. 1,2) in the gland, allows an estimate to be made of the amount of the three different materials that would have been used by the 10 g shrimp in one day. Table II shows the number of calories contributed by each of these compounds, as well as the amount of oxygen required for their complete oxidation, and the carbon dioxide produced in metabolizing these substrates.

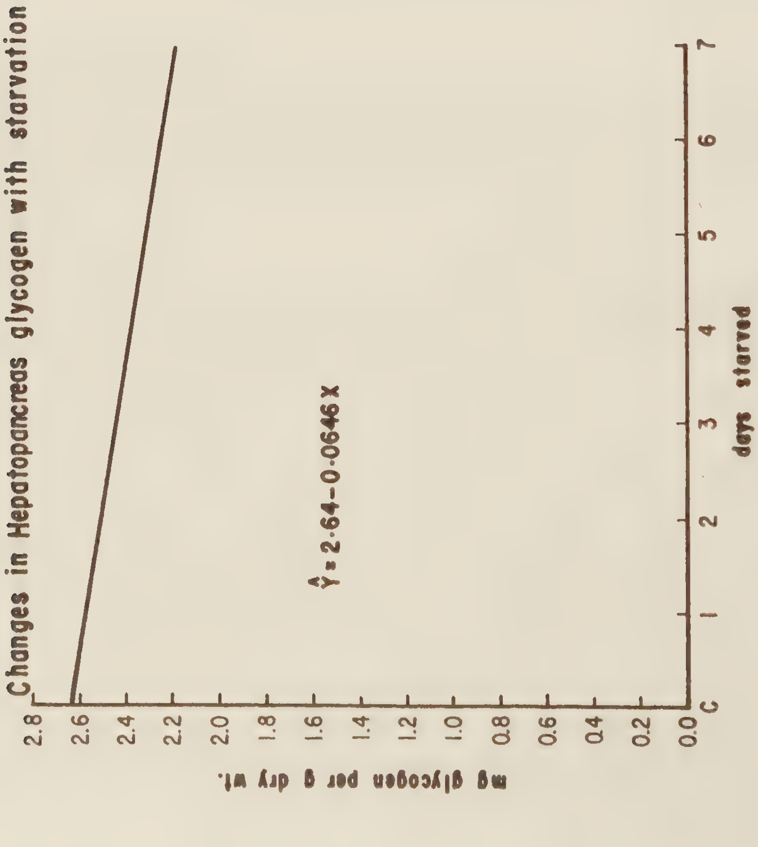
Changes in Hepatopancreas glycogen with starvation
$\hat{Y} = 2{\cdot}64 - 0{\cdot}0646X$
mg glycogen per g dry wt.
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
days starved

Fig. 1

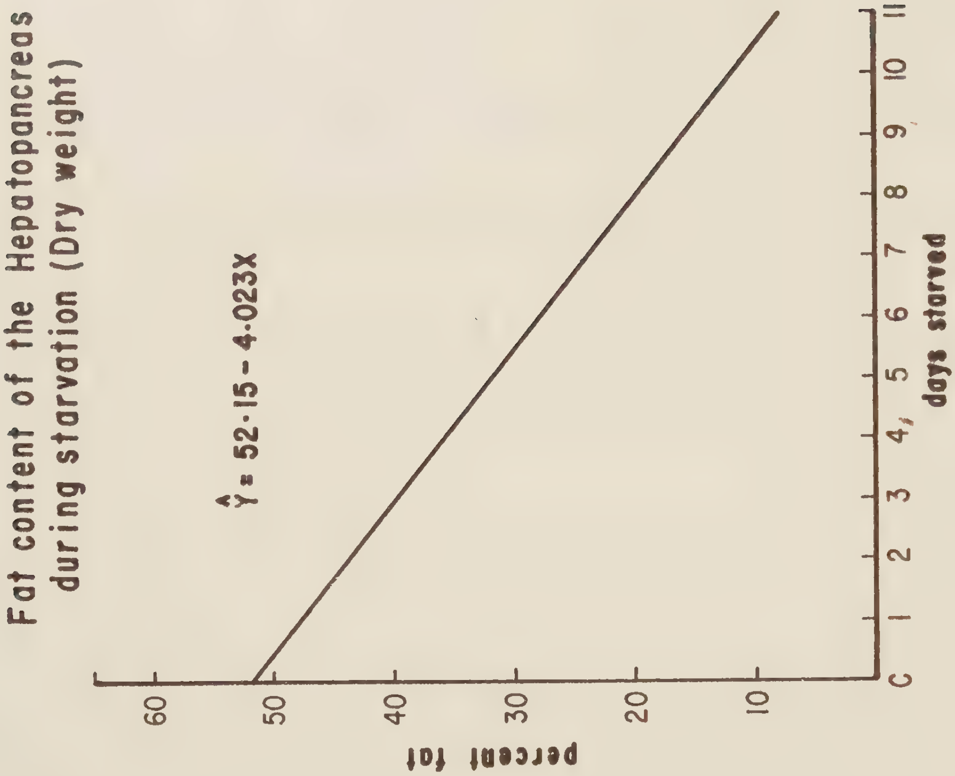
Fat content of the Hepatopancreas during starvation (Dry weight)
$\hat{Y} = 52{\cdot}15 - 4{\cdot}023X$
percent fat
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
days starved

Fig. 2

Table I contains a summary of the calculationsof the material flux through a 10 g shrimp. Examination of the number of calories made available by the storage material suggests that during starvation P. duorarum derives most of its energy from fats (85.81%) and protein (14.07%).

TABLE I

Substrates utilized, caloric content, O_2 and CO_2 changes in the hepatopancreas of starved P. duorarum of 1-g live weight per day

Substrate	Weight (μg)	Caloric content (kcal)	O_2 Consumed (ml)	CO_2 Produced (ml)
Protein	3292.75	14.207	3.182	2.548
Fat	9160.10	86.664	18.497	13.074
Carbohydrate	29.10	0.122	0.024	0.024
Total		100.993	21.703	15.546

TABLE II

Caloric content, O_2 consumed and CO_2 released by different substrates per day (1962 samples)

Substrate	kcal/g	ml/g O_2 Consumed	ml/g CO_2 Produced
Protein	4.1-4.316	966.3	733.9
Fats	9.3-9.461	2019.3	1427.3
Carbohydrate	4.1-4.182	828.8	828.8

Carbohydrate contributes only 0.12 percent to the energy pool. These results agree with those of Neiland and Scheer (1953), who found that fasting crabs use protein or lipids in preference to glycogen. The maximum glycogen content of the hepatopancreas of normal (i.e., fed) individuals was 8.63 mg/g. The hepatopancreas of a 10 g shrimp weighs only 383 mg (Fig. 3). This organ contains only 3.31 mg total glycogen. Metabolizing this amount of carbohydrate would provide at most 13.776 calories, which is only a little over 13 percent of the calculated daily caloric need of P. duorarum (Tables I and II).

This shift in reserves is common in starved animals. Determinations of respiratory quotients (R.Q.) have been employed to determine the relative proportions of types of foods being oxidized (Fruton and Simmonds, 1959; Prosser, 1952; Wolvekamp and Waterman, 1960). The interpretation of R.Q.s must be done with caution since in Crustacea interaction of CO_2 with the exoskeleton may give rise to abnormal R.Q. values (Wolvekamp and Waterman, 1960). When only carbohydrates are metabolized, the R.Q. is 1, while for fats alone it is 0.707. When proteins are metabolized the R.Q. is variable and depends on how far they are metabolized (Fruton and Simmonds, 1959). Using the assumptions of Table I, the respiratory quotients of starved P. duorarum is 0.721, which agrees very well with those given by Wolvekamp and Waterman (1960) for starved Crustacea (Table III).

Table III also shows that when the animals are fed, the R.Q. shifts to a higher value, indicating a possible shift towards greater participation of carbohydrates in metabolism. The total oxygen consumption calculated in Table I may be expressed as 90.4 μl of oxygen per hour per gram wet weight. This value falls well within the range of values given by Wolvekamp and Waterman for the oxygen consumption by Crustacea and is comparable to the value obtained by Zein-Eldin (1961) for P. aztecus Ives of 130 ml/g/h.

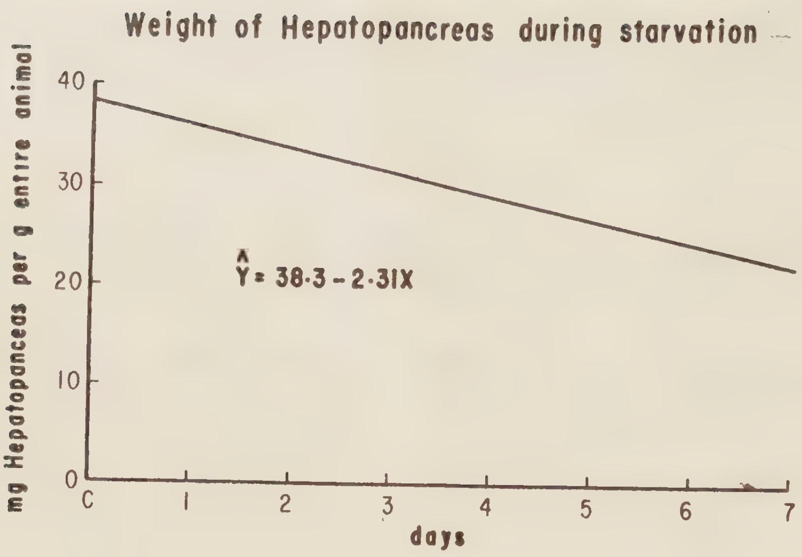

Fig. 3

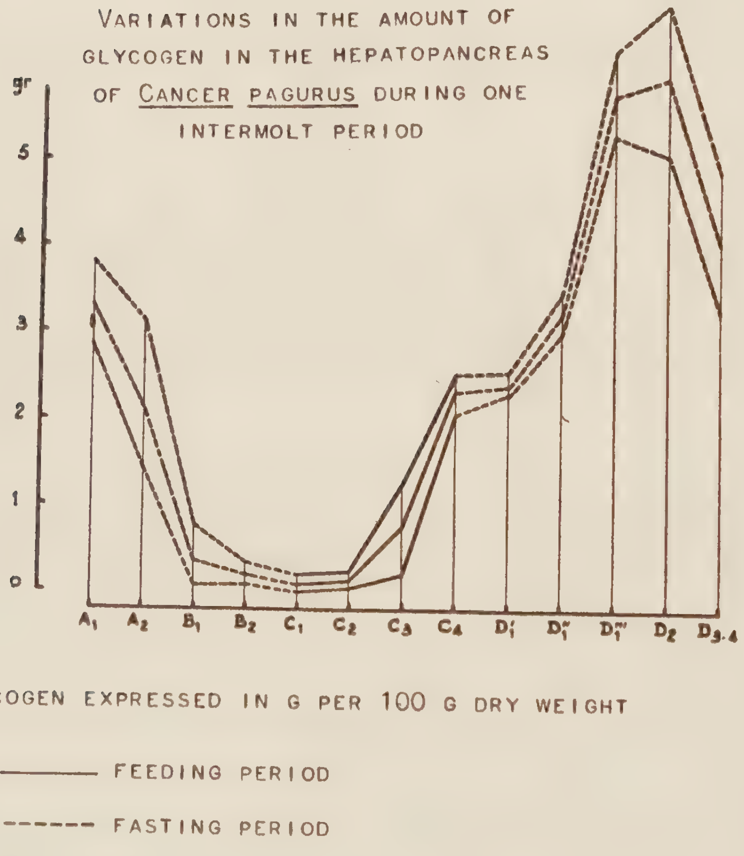

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Fig. 4

Only those values for oxygen consumption above 20°C were included in the Table, since all animals in the present study were maintained above 20°C during the experiments.

4.2 Changes in the hepatopancreas

P. duorarum showed a reduction in size, together with alterations in composition of the hepatopancreas, with induced starvation. The fat content of the gland decreased markedly with continued starvation. The glycogen content of the hepatopancreas declined with increasing starvation. The molting cycle is accompanied by changes in the composition and size of the hepatopancreas in Crustacea (Renaud, 1949; Passano, 1960). It may well be that these changes are partially due to the obligatory fasting period during the cycle and thus can be equated to the changes observed in *P. duorarum* during their experimentally induced fast. The dry mass varies from a minimum value at stage C_1 of the molting cycle to a maximum of three times the minimum size at stage D_1 (Passano, 1960). The mass then declines somewhat during D_2 and remains nearly constant until A, declining after this to a minimum at C_1. During the molting cycle, the major part of the hepatopancreas organic reserves accumulated during C_4 consists of lipids (Passano, 1960). The fatty acid content of *Cancer pagurus* Linn. was tripled during the feeding period, C_1 to D_1, and most accumulation occurred during C_4 (Renaud,1949). By D_3, hepatopancreas lipids showed a high turnover rate and almost disappeared by stage C (Passano, 1960). The decrease in lipids during starvation in samples in the present experiment paralleled the decrease in lipids shown during obligatory fasting from stages D_2 to C_1 in crustaceans. It has been shown (Bliss, 1953) that if both eyestalks of the land crab *Gecarcinus* are removed, the animals assume a state of proecdysis and the R.Q. falls from 0.77 to 0.69. The latter R.Q. agrees with the estimate here of an R.Q. of 0.721 for starved *P. duorarum*. This suggests that starved crustaceans, whether the condition is induced experimentally or naturally, metabolize fats to a greater extent than other reserves.

TABLE III

Respiratory Quotient (R.Q.) of crustaceans(Modified from Wolvekamp and Waterman, 1960)

Species	Temp. °C	R.Q.
Daphnia pulex	20.0	1.03 average 1.13 fed 0.71 starved
Palaemon serratus	15.8 17.3	0.9-0.95 fed 0.74 starved
Astacus astacus (F)	14.0	0.91 fed 0.72 starved
Astacus astacus (M)	11.5	0.93 fed 0.76 starved

F - females, M - males

During the molting cycle of crustaceans, hepatopancreas glycogen increases through the intermolt period and continues to do so during the early portions of the proecdysal period (D) (Passano, 1960). After stage D_2, the glycogen content decreases until it reaches a low at C_1 (Fig. 4).

The glycogen content of the hepatopancreas of P. duorarum decreased during starvation. Calculations indicate that if all the glycogen in the hepatopancreas of these animals were metabolized it would provide only 13 percent of the caloric requirement for one day.

Passano (1960) states that "nearly 70 percent of the protein nitrogen of Cancer found at stage D has been calculated to be utilized in the succeeding ecdysis. Soluble nitrogen representing catabolic products of protein and purine breakdown, essentially parallels the changes in protein, although it is slightly higher from D_2 through D_4."

Neiland and Scheer (1953) indicate that Hemigrapsus uses protein rather than carbohydrate and fat as primary energy source, during starvation. Present results show no significant changes in the nitrogen level of the hepatopancreas of P. duorarum with starvation, but since the gland becomes smaller as starvation proceeds, the absolute level of protein (nitrogen) diminishes with starvation (Fig. 3). Calculations indicate that about 14 percent of the caloric requirements of starved animals were met by protein metabolism. Needham (1956) has shown that in the isopod Asellus, nitrogen excretion (NH_3 and amino nitrogen) increased just prior to exuviation and reached a maximum shortly after. This was followed by a decline in nitrogen excretion. The increase in nitrogen excretion suggests an increase in the catabolism of nitrogen-bearing substrates and may be due to increasing use of protein as a substrate. On the other hand there is a possibility that acetylglucosamine, from the breakdown and reabsorption of chitin by-products prior to molting, is being oxidized to CO_2, as was demonstrated in rats by Kohn, Winzler and Hoffman (1962). Work by the authors cited, the results obtained on the changes in storage materials from the hepatopancreas of P. duorarum during induced fasting, and the chitin resorption of 70 percent indicated by Schafer (1967), suggest that glycogen and fat are stored in the hepatopancreas during intermolt. It appears that during the obligated fast after molting, fat and protein are utilized by the animals and chitin formation is greatest during this period. Prior to ecdysis, chitin is resorbed and its components may be utilized in the general metabolic processes.

5 SUMMARY

When pink shrimp, P. duorarum, are starved they metabolize mainly fat reserves and protein. The size of the hepatopancreas decreases with increasing starvation and its composition is altered. Fat stores in the hepatopancreas decrease markedly during starvation, and glycogen stores also decrease.

Carbohydrate storage material seems to play a minor role in maintaining these animals alive during starvation, but it probably contributes more during the period in which they feed. A review of the literature indicates that carbohydrates are probably of great importance as intermediates for the interconversion of other reserves.

The changes observed in the size and composition of the hepatopancreas of starved animals seem to parallel those reported during the molting cycle of other Crustacea. It is suggested that these changes are brought about to some extent by the obligatory fast imposed on Crustacea by the molting cycle. It is indicated that during the postmolt period, chitin synthesis is most active. During the intermolt period, carbohydrates probably contribute considerably to the energy requirements of the animals. During stage D_2 of the premolt period, the animals cease to feed and fat stores as well as protein reserves are metabolized. It is possible that at this time the breakdown products of chitin resorption may play a role in the metabolic processes.

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ESTUDIO PRELIMINAR SOBRE LAS MIGRACIONES DE POSTMISIS DE *Penaeus vannamei* BOONE

por

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Extracto

Se proporcionan datos referentes a la biología de las cuatro especies comerciales de *Penaeus* de las costas del Pacífico mexicano. Se determina que las postmisis (principalmente de *Penaeus vannamei*) invaden las aguas protegidas de la boca de entrada al Puerto de Mazatlán, Sinaloa, entre principios de primavera y fines de verano, mientras que al sur de Mazatlán continúan entrando todo el año. Se buscan los factores en el medio ambiente que podrían influir sobre estas migraciones.

PRELIMINARY STUDY OF THE MIGRATIONS OF THE POSTMISIS OF *Penaeus vannamei* BOONE

Abstract

Information was collected on the four commercial species of *Penaeus* of the Mexican Pacific Coast. It was found that the postmisis (mainly *Penaeus vannamei*) enter the still waters of the entrance channel of the port of Mazatlán (State of Sinaloa), from early spring to late summer, while to the south of Mazatlán they enter throughout the year. The ecological factors which might influence these migration are sought.

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ETUDE PRELIMINAIRE SUR LES MIGRATION DES POSTMISIS DE *Penaeus vannamei* BOONE

Résumé

L'auteur fournit des renseignements sur la biologie des quatre espèces commerciales de *Penaeus* que l'on recontre le long des côtes mexicaines du Pacifique. On observe que, du début du printemps a la fin de l'été, les postmisis (surtout de *Penaeus vannamei*) envahissent les eaux abritées du chenal d'entrée du port de Mazatlán (Etat de Sinaloa) alors qu'au sud de cette ville leur pénétration dure toute l'année. L'auteur étudie les facteurs écologiques qui pourraient influer sur ces migrations.

1 INTRODUCCION

Los estudios sobre los ciclos biológicos de los camarones del noroeste de México han sido apenas parciales, y la información de que se dispone sobre ellos es escasa. En este trabajo se trata de resumir brevemente los datos que existen, a manera de una introducción al problema.

El camarón blanco del Pacífico (Penaeus vannamei) y el camarón azul (Penaeus stylirostris) desovan en mar abierto, precisamente en el área en donde se realiza la pesca (Chapa, 1956). Los óvulos al ser expulsados son fecundados por los espermatozoides contenidos en el espermatóforo previamente colocado por el macho en el télico de la hembra. Los huevecillos, por ser demersales (Pearson, 1939), se hunden prontamente. Según este mismo autor, el desarrollo larval comprende doce estadios: cinco incluidos bajo el nombre de nauplio, tres de protozoea, dos de misis y dos de postmisis (estadios larvales que preceden a la forma verdaderamente adulta). Bajo estas formas el camarón es planctónico y se ha movido desde los lugares de desove hasta las aguas protegidas constituidas por las marismas, esteros y bahías, donde entre en forma de postmisis, sustituyendo otras poblaciones que habían entrado con anterioridad. Al alcanzar el estado adulto inicia el movimiento inverso, es decir hacia mar abierto, influenciado por la luna y las mareas; de este hecho se aprovechan las cooperativas que existen en el sur del Estado de Sinaloa y en el norte de Nayarit, para pescarlo a su salida. Los ejemplares que logran salir al mar y sobrevivir a la pesca que se realiza en mar abierto, son los encargados de reiniciar el ciclo. Al bajar la temperatura y el volumen de las aguas interiores, las últimas poblaciones que se quedan en los remanentes de estas aguas y sobreviven a las condiciones adversas del medio, al empezar la primavera comienzan a dirigirse hacia mar abierto (Chapa, 1956).

El camarón café (Penaeus californiensis) y el camarón cristalino (Penaeus brevirostris) tienen un ciclo biológico semejante, y sólo difieren del citado anteriormente en que los estadios postmisis no penetran forzosamente a las aguas interiores.

El problema que se aborda en este trabajo es el de determinar la época de entrada de las postmisis de camarón a aguas interiores y su identificación a nivel específico, puesto que al conocer estos datos se podrá afrontar una serie de problemas prácticos involucrados en la pesca de camarón en aguas interiores, tales como vedas, colocación de tapos en su debido tiempo, desazolves y aumento del volumen de las aguas mediante inyecciones de agua dulce.

2 MATERIALES Y METODOS

Como se expresa en líneas anteriores el problema puede dividirse en dos aspectos: (a) determinar la época de entrada de las postmisis de camarón a aguas interiores; (b) identificación a nivel específico de dichas postmisis.

En relación con el punto (a), se realizaron muestreos periódicos cada 10 días, uno en la mañana y otro en la noche, en tres estaciones de colecta situadas en la boca del Puerto de Mazatlán (Fig. 1): la primera fuera de la escollera del puerto (Et. 1); la segunda dentro del canal de navegación (Et. 2); y la tercera al final del canal de navegación y principios del Estero de Urías (Et. 3). Dichos muestreos se iniciaron el primero de febrero de 1966 y se terminaron el 15 de octubre del mismo año. Los muestreos se interrumpieron en dos ocasiones por dificultades técnicas.

Se utilizó una lancha de 18 pies (5,5 m) que arrastró durante 10 minutos una red de plancton de una longitud de 90 cm por 30 cm de diámetro y con una malla de 0,203 mm (malla No. 8). En todos los muestreos se procuró uniformar todas las condiciones de colecta y se tomaron los datos ecológicos habituales.

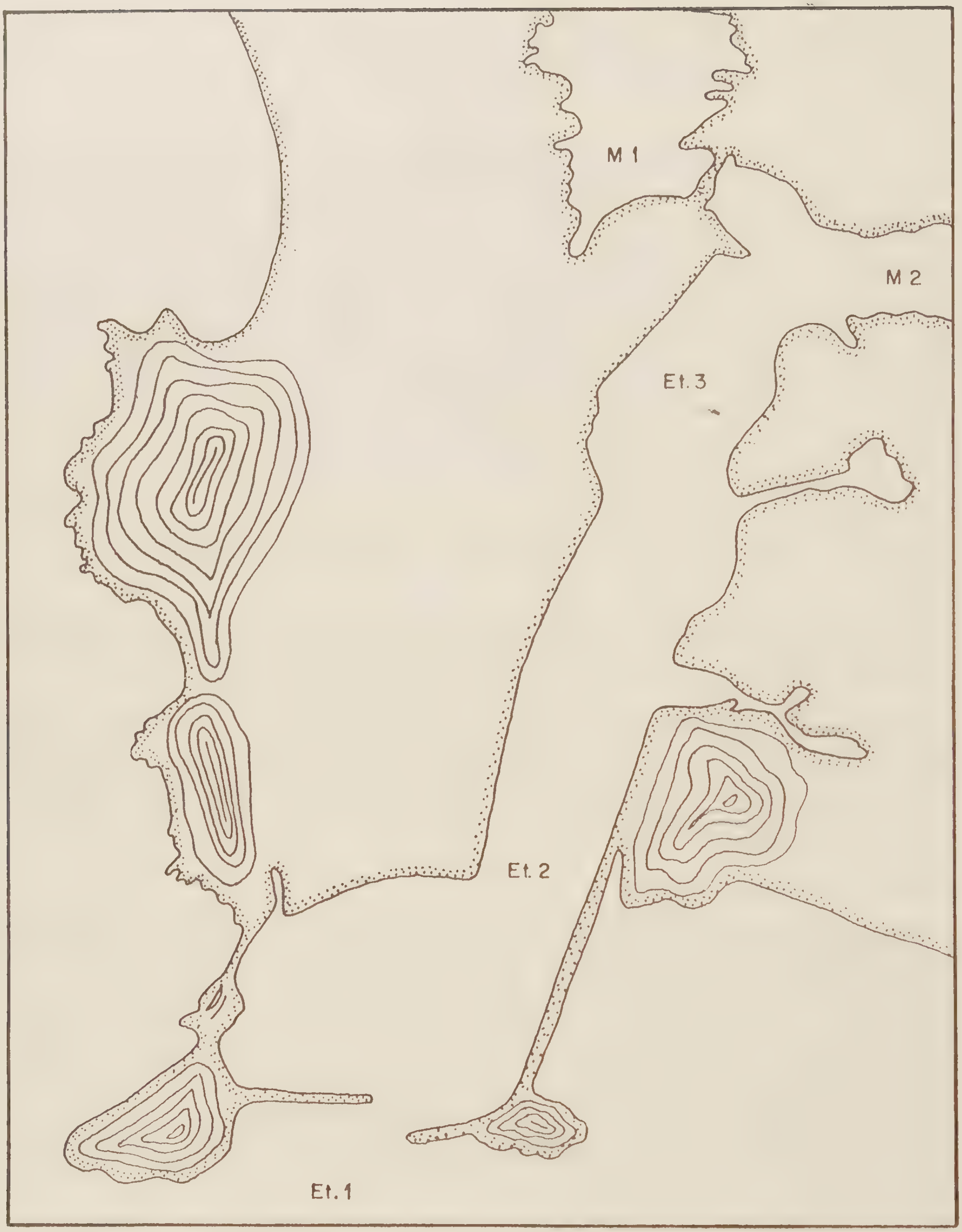

Fig. 1 Boca del Puerto de Mazatlán, con estaciones de colecta.

Las colectas se preservaron en formol al 4 por ciento en agua de mar. Las muestras fueron examinadas al microscopio de disección para observar la incidencia de postmisis; luego se separaron, contaron, midieron y transparentaron con KOH al 10 por ciento, 50 ejemplares de cada muestra, o menos si la colecta no contenía este número.

Como complemento se efectuaron pruebas de supervivencia en distintas salinidades, colocando grupos de 10 individuos; se midió también el tiempo de supervivencia.

En relación con el punto (b), lo ideal sería realizar un cultivo de camarones capturando hembras con espermatóforo adherido y mantenerlas vivas en el laboratorio para luego lograr la expulsión de los huevos fecundados e ir separando los distintos estadios del desarrollo hasta llegar cuando menos al estadio de postmisis igual al que tienen las capturadas por nosostros en nuestros muestreos. Como tal procedimiento era difícil o imposible, se optó por mantener las postmisis en el laboratorio hasta alcanzar su estado adulto, para así identificarlas a nivel específico. Este trabajo aún no se ha terminado, pero mientras tanto y para darnos una idea, aunque no definitiva, de la identidad específica de estos estadios, se efectuaron los trabajos siguientes: (a) muestreo de camarón adulto en el Estero de Urias. Dicho muestreo se realizó con atarraya, capturándose 1000 ejemplares, 500 en M 1 y 500 en M 2 (Fig. 1); (b) muestreo en el muelle de Mazatlán.

Para obtener los datos referentes a la madurez de los camarones, se utilizaron los datos obtenidos de los muestreos de camarones procedentes de aguas marinas que la Estación de Biología Pesquera de Mazatlán, Sinaloa, realiza con diversos fines.

3 EPOCA DE ENTRADA DE POSTMISIS A AGUAS INTERIORES

Cárdenas (1951) encontró que la época de desove para P. vannamei y P. stylirostris empieza a fines de febrero y termina en junio. Si tenemos en cuenta que el estado de postmisis se alcanza en tres semanas a partir de la puesta, según los datos de este autor la época de entrada de estos estadios a aguas interiores sería desde mediados de marzo hasta mediados de julio.

Chapa (1961) informa haber capturado multitud de postmisis de camarón durante el mes de mayo en la bahía de Mazatlán y la Barra de Teacapán.

Nosotros encontramos una pequeña afluencia en los meses de marzo y abril, que casi desaparece en el mes de mayo. Desafortunadamente el muestreo se suspendió el 20 de mayo, para reanudarse el 21 junio, cuando se notó ya una influencia mayor, que alcanzó su máximo el día 11 de julio, o sea en pleno verano. Esta afluencia decreció bruscamente el día 2 de agosto y a partir de esa fecha era fluctuante, para desaparecer en los muestreos el día 30 de septiembre (Fig. 2).

Al revisar unos muestreos realizados por el Sr. R. Soto López en la boca del Río Presidio (Villa Unión, Sinaloa) encontramos dos postmisis el día 7 de octubre y han continuado apareciendo de una manera irregular hasta enero de 1967.

4 IDENTIFICACION DE POSTMISIS CAPTURADAS

Como se indicó en el capítulo referente a materiales y métodos, se planeó mantener los ejemplares vivos en el laboratorio hasta que alcancen su estado adulto, para así identificarlos a nivel específico. Dicho trabajo aún no se ha terminado, pero mientras tanto nos servimos de los siguientes argumentos que nos hacen suponer que se trata de postmisis de P. vannamei:

(a) P. vannamei representa alrededor del 95 por ciento de las capturas de camarón en aguas protegidas del sur de Sinaloa;

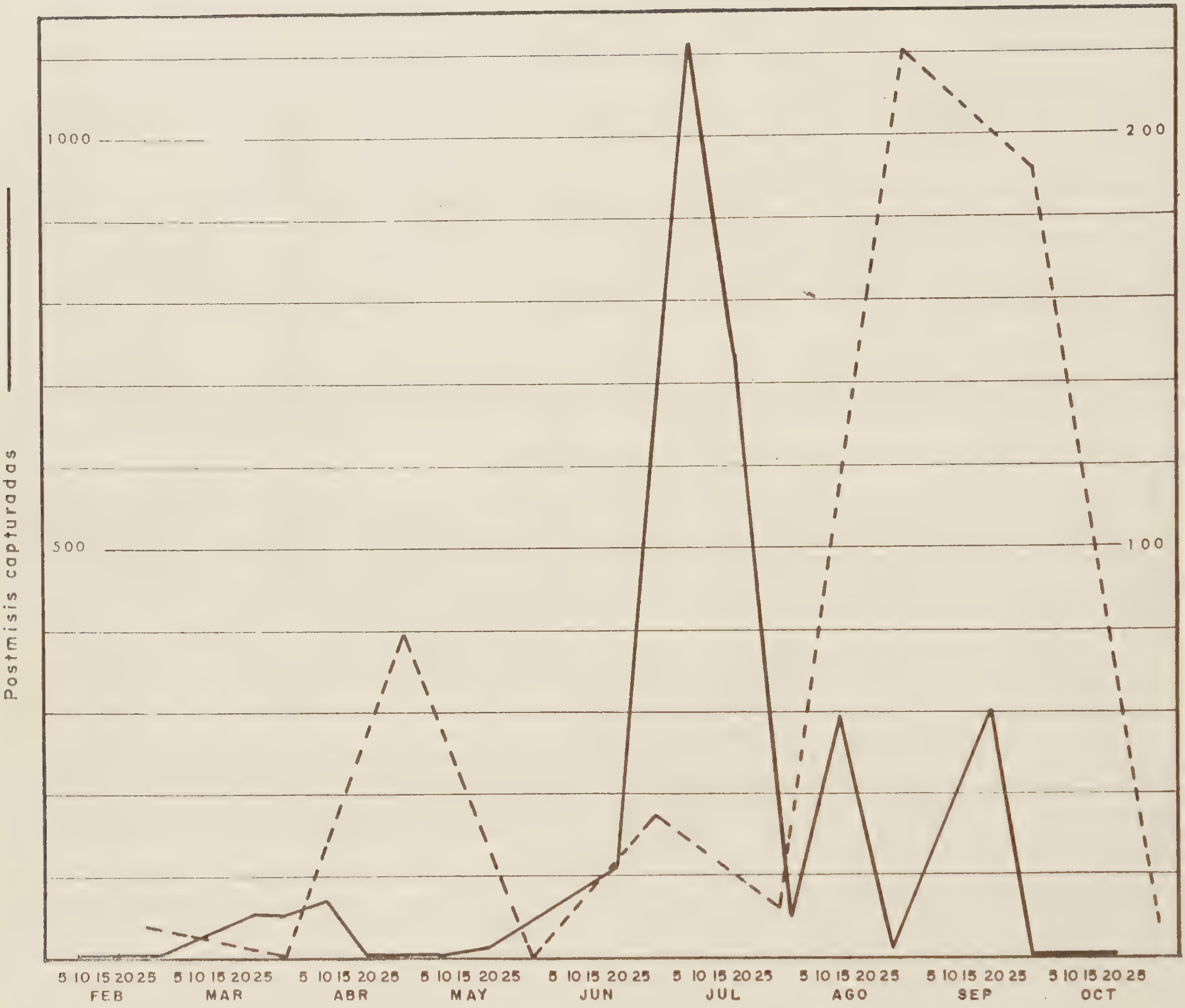

Fig. 2 Correlación entre postmisis y precipitación.

(b) P. vannamei tiene hábitos diurnos, al igual que las postmisis capturadas por nosotros;

(c) Al examinar los datos obtenidos por Chapa (1956), encontramos que P. stylirostris, que sería la especie que podría estar mezclada con P. vannamei por la semejanza en sus ciclos vitales y hábitos, se encuentra en aguas costeras cercanas a la zona de nuestro estudio, en un porcentaje que va desde 1,11 hasta un 22,70 por ciento. Pero encontramos que en la época cuando se supone se realiza el desove, esta especie se encuentra presente en esta zona en un mínimo porcentaje;

(d) En los muestreos realizados en el Estero de Urías en M 1 y M 2 (Fig. 1), se colectaron 500 ejemplares en cada estación, los cuales en su totalidad fueron P. vannamei;

(e) Las postmisis examinadas presentan una talla y morfología semejante por lo que es de suponerse que pertenecen a una sola especie.

5 ECOLOGIA

Como parte de este estudio se obtuvieron los datos ecológicos presentes en la boca donde se realizó el trabajo, con la intención de encontrar posibles relaciones entre la variación del medio físico y la entrada de las postmisis de P. vannamei.

5.1 Temperatura

La temperatura superficial del agua en la boca del puerto a mediados del verano, cuando entra el máximo de postmisis, es de 30°C, con una variación diurna de 2°C. Este factor, entre otros, podría determinar las migraciones de P. vannamei de aguas interiores hacia mar abierto.

5.2 Salinidad, turbidez y precipitación pluvial

Las variaciones de la salinidad y de la turbidez en aguas protegidas generalmente van asociadas; nosotros encontramos mínimas variaciones en estos factores a lo largo del tiempo que duró nuestro estudio, ya que esta zona está muy influenciada por el ambiente marino. Se encontró que el máximo de postmisis penetra en aguas interiores inmediatamente antes de que se presente el máximo de precipitación pluvial en la zona (Fig. 2). Esta precipitación no altera sensiblemente la salinidad en la boca, pero sí la abate dentro de los esteros. La baja salinidad es mencionada por algunos autores como un factor que influye en estas migraciones. Nosotros encontramos, al menos en el año en que se realizó el estudio, que esta influencia se presenta hasta que las postmisis han entrado en los esteros, por lo que pensamos no influye de manera directa para provocar la migración. En relación con este punto se sometieron grupos de 10 ejemplares de supuestas postmisis de P. vannamei a distintas salinidades, encontrándose que a una temperatura de 23°C, sobreviven en salinidades desde 7 hasta 45°/oo. Por otra parte, es innegable la importancia de una baja en la salinidad, si no para la supervivencia, sí para el crecimiento de estos organismos dentro de los esteros, ya que existe una relación directa entre el volumen de la producción camaronera en aguas interiores con la precipitación pluvial.

5.3 Acidez

El pH en la zona de muestreo permaneció también muy estable y se mantuvo alrededor de 6,5 durante el período de las colectas.

5.4 Organismos asociados

Se hizo un análisis somero de las muestras colectadas con el fin de observar de una manera general a los organismos asociados con las postmisis, pues hay muy poco estrito al respecto.

Se observó una gran abundancia de las diatomeas Nitzschia y Rhizosolenia que en ocasiones llenaron las redes de plancton. Esta abundancia fué muy irregular y no se encontró relación alguna con la abundancia de postmisis.

Larvas de crustáceos, sobre todo de braquiuros, fueron abundantes y aparecieron de una manera más o menos constante a lo largo de nuestro estudio. Es posible que estos organismos compitan con las postmisis de P. vannamei.

Eufausiáceos y misidáceos son a veces muy abundantes, sobre todo los últimos, llenando en ocasiones las redes de plancton. Se observó que cuando las colectas fueron abundantes en misidáceos, las postmisis fueron muy escasas.

Los copépodos estuvieron siempre presentes y en porcentajes más o menos constantes.

Celenterados y tenóforos son predadores de un gran número de pequeños crustáceos, entre ellos de las postmisis objeto del estudio; aparecieron en nuestras muestras de una manera irregular y ocasionalmente se encontraron postmisis en su interior.

6 CONCLUSIONES

El presente trabajo constituye el primer intento para la determinación de la época de entrada de las postmisis de P. vannamei a aguas interiores.

Se pueden señalar como resultados positivos los siguientes:

(a) Las postmisis entran a aguas interiores desde marzo hasta septiembre, con un máximo a mediados de julio, es decir, entran durante la primavera y el verano. Esto sucede en la boca de entrada al Puerto de Mazatlán, pero en la boca del Río Presidio situada un poco al sur, continúan entrando después de esta fecha, aunque de una manera muy irregular;

(b) Las poblaciones entrantes son semejantes en su morfología, homogéneas en talla y estado de desarrollo. Posiblemente son monoespecíficas, y pertenecientes a la especie P. vannamei;

(c) Se encontró que la época en que entra el máximo de postmisis es previa a la máxima precipitación pluvial, lo cual favorece aparentemente el crecimiento de estos organismos mediante el abatimiento de la salinidad y aumento del volumen de las aguas en los esteros;

(d) Se encontró que las postmisis de P. vannamei sobreviven en salinidades que van de 7 hasta 45°/oo;

(e) Estos resultados no deben tomarse como definitivos sin antes efectuar otras experiencias.

7 RECOMENDACIONES

Como se expresó en capítulos precedentes, es fundamental realizar cultivos en el laboratorio, de las cuatro especies comerciales de Penaeus del Pacífico, o cuando menos experiencias como la que estamos realizando al tratar de lograr que las postmisis capturadas alcancen su estado adulto para así poderlas clasificar y tener la absoluta seguridad de su identidad.

Para rectificar los resultados obtenidos, es conveniente repetir el ciclo de muestreo y que éstos no sean exclusivamente superficiales, sino de preferencia a distin estratos o en su defecto oblicuos, con el fin de tener un conocimiento completo de la biomasa.

Sería conveniente que los "tapos" del sur de Sinaloa y norte de Nayarit, se modificaran empleando tela de alambre con malla de 11 x 16 mm, en lugar de la manga de palapa, llamada "sierra" que si no impide por completo el paso de las postmisis (con talla promedio de 11 mm) sí presenta un serio obstáculo, difícilmente vencido por dichas postmisis en su migración, ya que presenta una luz muy pequeña. Aunque dichas "sierras" no están colocadas durante la época de máxima entrada de postmisis (julio y agosto), sí lo están desde el primero de septiembre hasta el 15 de abril; y teniendo en cuenta que las postmisis continúan entrando, aunque en menor escala y de manera irregular durante este lapso de tiempo, creemos que la sierra de manga de palapa impide el total aprovechamiento de estas poblaciones entrantes de camarón.

Al realizar un estudio más completo, se podrá relacionar la abundancia anual de postlarvas de P. vannamei con la captura comercial en aguas protegidas del sur de Sinaloa y norte de Nayarit.

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MORFOLOGIA DE *Macrobrachium acanthurus* (WIEGMANN) EN EL ESTADO DE VERACRUZ, MEXICO

por

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Extract

Se proporciona una descripción morfológica del camarón palemónido *Macrobrachium acanthurus*, indicando las variaciones encontradas en los especímenes muestreados en cuatro lugares de la costa del Golfo de México.

MORPHOLOGY OF *Macrobrachium acanthurus* (WIEGMANN) IN THE STATE OF VERACRUZ, MEXICO

Abstract

The morphology of the palaemonid shrimp *Macrobrachium acanthurus* is described, with indications regarding the variations encountered in samples collected in four locations on the coast of the Gulf of Mexico.

MORPHOLOGIE DU *Macrobrachium acanthurus* (WIEGMANN) DANS L'ETAT DE VERACRUZ, MEXIQUE

Résumé

Les auteurs fournissent une déscription morphologique de la langoustine de la famille Palaemonidae *Macrobrachium acanthurus*, en signalant les variations qu'on a trouvées dans les échantillons en quatre endroits du Golfe du Mexique.

1 INTRODUCCION

Una de las pesquerías que en el Estado de Veracruz pasa casi inadvertida es la del llamado comúnmente "camarón prieto", "acamaya" o "camarón de río", Macrobrachium acanthurus (Wiegmann), pues aunque su captura se realiza en aguas dulces, generalmente se vende al público como camarón de mar o se consume como tal en los expendios de mariscos. Es tan importante el volumen de su producción que en el año de 1966 una sola sociedad cooperativa pesquera capturó cerca de 150 toneladas, con un valor de casi dos millones de pesos mexicanos [1].

Con el objeto de contribuir al conocimiento de la biología de esta especie, se presenta el estudio morfológico y descriptivo de los ejemplares de cuatro localidades en el Estado de Veracruz.

Se hace patente el agradecimiento al Dr. A. Villalobos F., por su atinada dirección para la realización del presente trabajo y a las personas que en una u otra forma colaboraron con el autor.

2 MATERIAL Y METODOS

Se usaron 261 individuos de Macrobrachium. A cada uno de los 126 procedentes del Arroyo Vergara de Playa Norte, (Puerto de Veracruz) se tomaron 27 medidas diferentes. Se midieron 52 ejemplares de Tecomate, Alvarado, 71 de Novillero, Boca del Río, y 12 de Pueblo Viejo, en los límites con el Estado de Tamaulipas. Las estaciones de colecta están indicadas en la Fig. 1. De los ejemplares procedentes de las últimas localidades se consideraron 14 medidas como las más útiles para efectos de comparación.

Las medidas fueron hechas con una regla graduada de 20 cm unida a una tabla en cuyo principio se colocó una lámina de aluminio en ángulo de 90°; para obtener la longitud total los individuos se dispusieron sobre la tabla y se extendieron de tal manera que la punta del rostro tocara la lámina de aluminio; para el resto de las medidas fue empleado un Vernier "Scala 222", con auxilio en algunas ocasiones del microscopio de disección.

La descripción morfológica fue enfocada sobre 12 ejemplares colectados durante seis excursiones realizadas al Arroyo Vergara entre los meses de marzo y junio de 1966; de cada colecta se estudiaron un macho y una hembra seleccionados al azar.

Las capturas fueron llevadas a cabo con el auxilio de dos redes de cuchara con boca rectangular, de 30 x 37 y 30 x 50 cm. Estas redes fueron deslizadas por el fondo, entre las raíces de las plantas flotantes, principalmente Eichhornia crassipes, entre ramajes sumergidos y en las orillas del arroyo.

Los ejemplares fueron preservados en alcohol etílico al 70 por ciento y debidamente etiquetados han quedado depositados en la colección del Centro Nacional de Ciencias y Tecnologías Marinas de Veracruz, con los números del 14 al 27.

3 DESCRIPCION MORFOLOGICA

3.1 Cefalotórax

El caparazón es liso, con cerdas cortas en la región anterolateral presentes sólo en los machos. Su contorno inferior presenta un refuerzo en forma de banda que se inicia en el ángulo branquiostegal. La espina antenal se encuentra debajo del reborde ocular y sobresale un poco del margen anterior; la espina hepática se halla situada un poco más atrás y debajo de la espina antenal. Un surco hepático se inicia por debajo de la espina hepática y termina en el tercio anterior del caparazón, inmediatamente

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[1] Un peso mexicano = E.U.A. $0,08

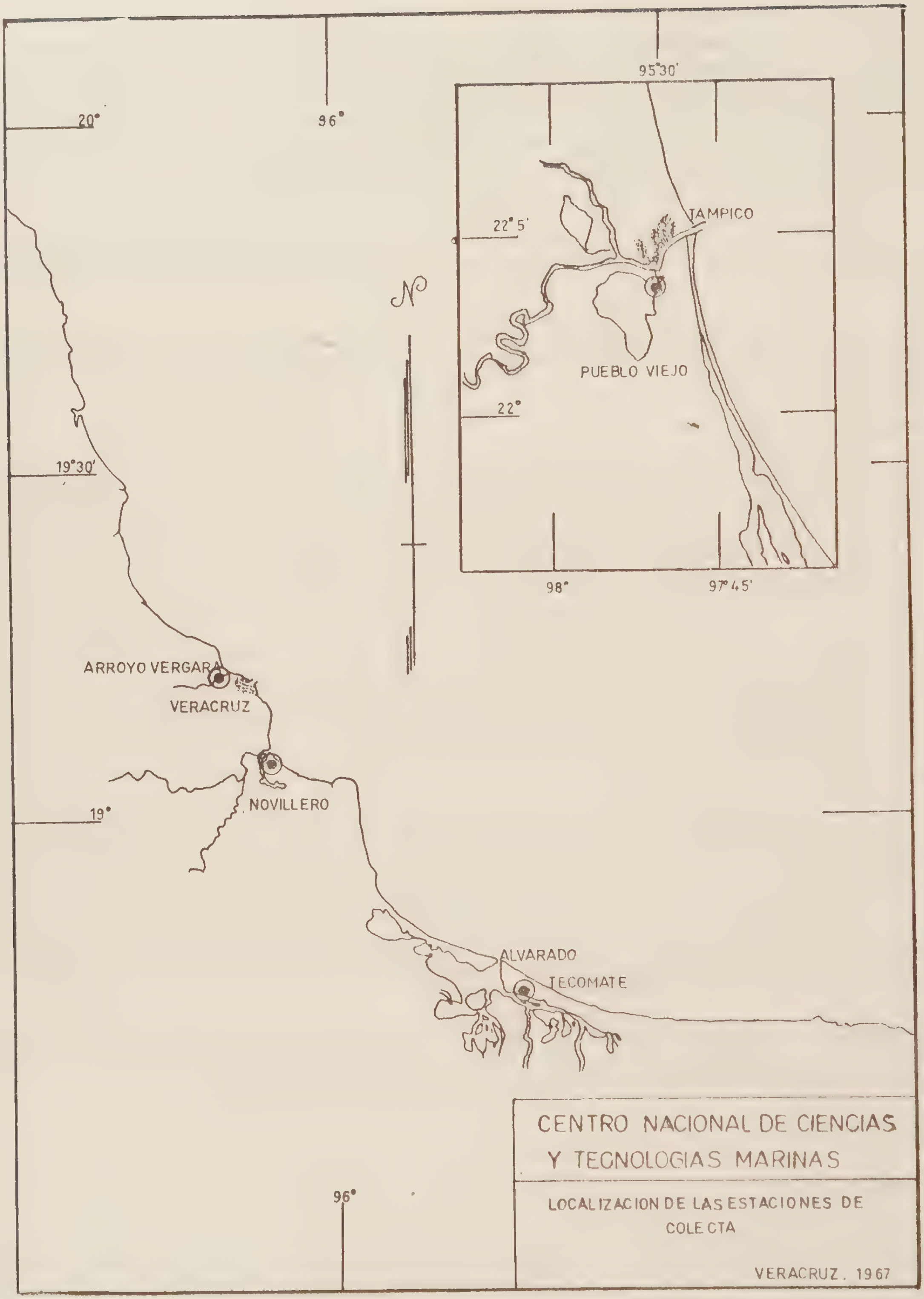


Fig. 1 Localización de las estaciones de colecta de Macrobrachium acanthurus

y un poco más arriba de este surco se presenta el branquial que forma una curvatura limitando la parte superior de la región branquial para terminar casi en el margen posterior del caparazón; un poco más arriba y en la parte anterior de este surco, se presenta una corta depresión de forma triangular. Se observa otra depresión muy leve un poco más arriba de la espina hepática.

El cefalotórax tiene las siguientes relaciones: el espacio comprendido entre el extremo posterior del surco hepático y el borde anterior del caparazón (Fig. 3.1) es la mitad de la distancia comprendida entre el extremo posterior del surco citado y el borde posterior del caparazón (Fig. 3.2).

La distancia dorsal entre un surco branquial y otro es la mitad de la longitud del surco hepático considerando hasta el extremo posterior del cefalotórax (Fig. 3.2). La distancia considerada verticalmente desde el final del surco hepático al perfil superior del cefalotórax (Fig. 3.5) es 3/4 de la altura mayor de la región branquial (Fig. 3.6) y es equivalente a la sección entre las espinas antenales. La máxima anchura del caparazón corresponde a la máxima altura. La distancia que media entre el ángulo infraorbital y el extremo posterior del surco hepático (Fig. 3.4) es semejante a la que existe entre este mismo punto y el perfil superior (Fig. 3.5).

La hembra es semejante, excepto que la distancia dorsal entre los surcos branquiales es mayor que la mitad de la distancia del surco hepático, considerada en la misma forma que en el macho (Fig. 3.4). La longitud dorsal del cefalotórax sin el rostro (Fig. 2.6) es la mitad de la distancia entre el ángulo suborbital y el borde posterolateral del cefalotórax (Fig. 2.9); la distancia entre los extremos de las espinas antenal y hepática (Fig. 3.3) es 1/4 de la anchura máxima del caparazón.

3.2 Rostro

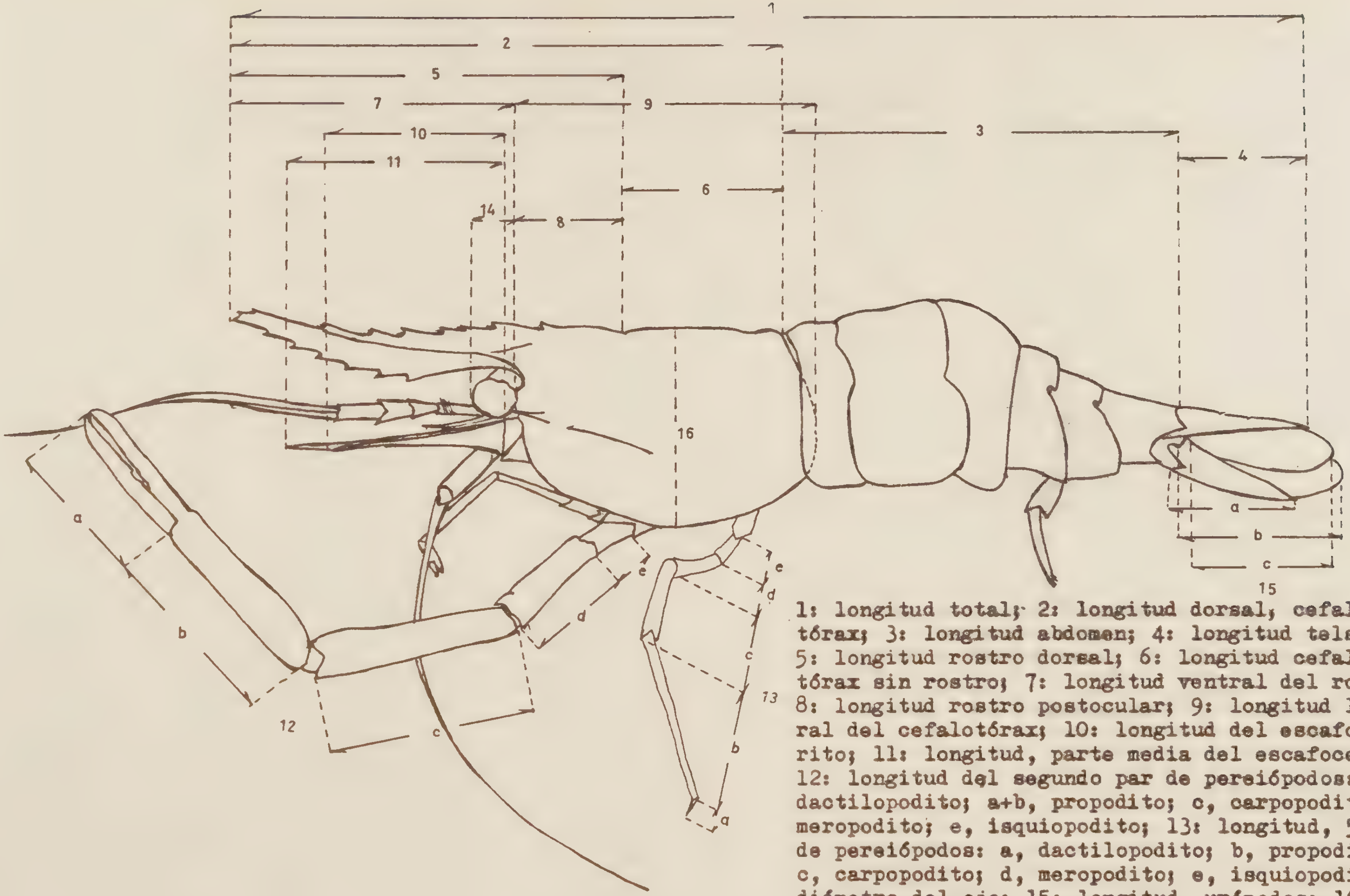
El rostro es agudo y comprimido, más corto dorsalmente que la longitud lateral del cefalotórax y ventralmente mayor que la mitad del mismo (Figs. 2.5, 2.9 y 2.7) con 8-9 dientes superiores colocados casi a la misma distancia, excepto el primero y segundo proximales que están separados por un espacio mayor y los dos distales más cercanos entre sí. El margen inferior tiene 4-6 dientes separados uno de otro por una distancia semejante. Los dos primeros dientes del margen superior están colocados detrás de la órbita ocular; el séptimo diente de esta misma quilla y el cuarto del margen ventral, están dispuestos a la altura de la porción media del tercer artejo distal del pedúnculo antenular (Fig. 3).

El rostro es ligeramente curvado hacia arriba, principalmente en su extremo distal. Su máxima altura se encuentra al nivel de los dientes 5/1. Lateralmente presenta un borde longitudinal que lo divide en dos superficies semejantes en anchura, la superior ligeramente acanalada y la inferior un poco menos cóncava; el borde mencionado es una continuación del reborde orbital, que se inicia a su vez a partir de la espina antenal y prosigue a todo lo largo del rostro hasta el octavo diente de la quilla dorsal (Fig. 2). Numerosas cerdas se insertan en el espacio comprendido entre los dientes; dorsalmente ellas se colocan en grupos antes de cada diente y ventralmente se encuentran en toda la longitud de la quilla, sobrepasando con su longitud la altura de los dientes. Por su longitud es más corto que el escafocerito.

El rostro de la hembra es semejante al del macho, excepto que es casi tan largo dorsalmente como la longitud lateral del cefalotórax y su altura máxima es menor.

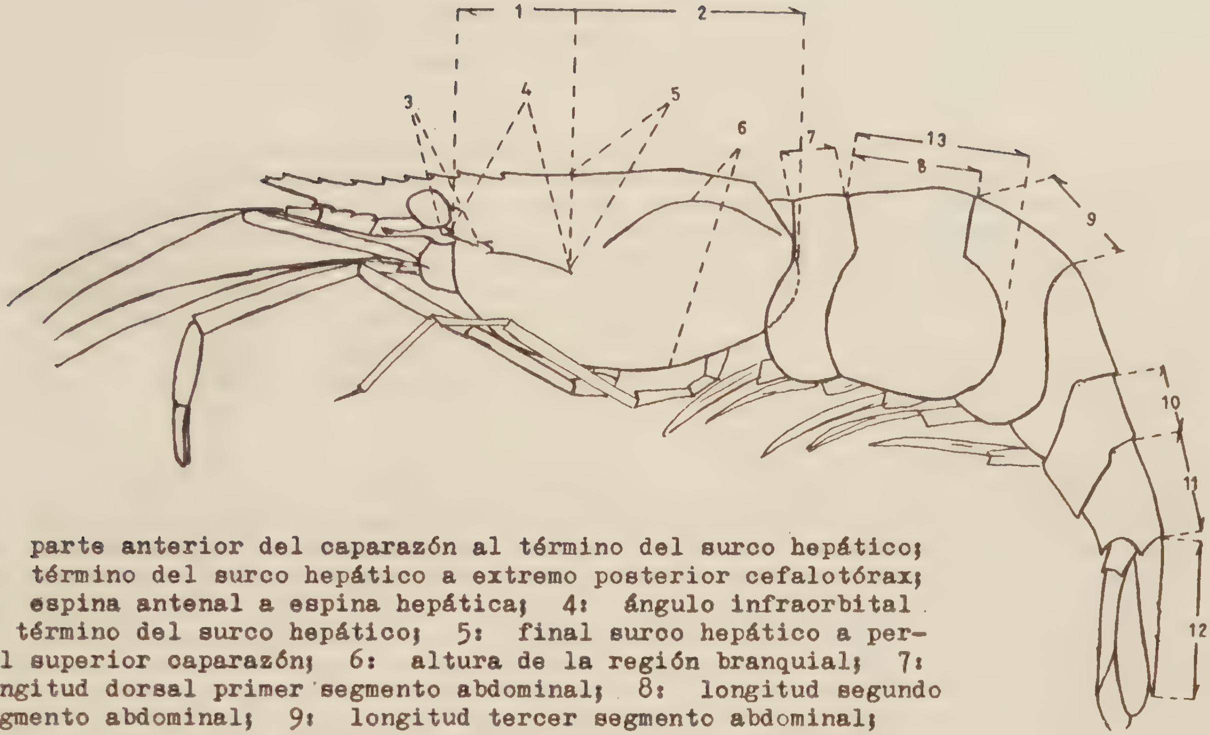
3.3 Apéndices cefálicos

3.3.1 Antena En la parte distal del basipodito se encuentra el exopodito, escama antenal o escafocerito. La longitud de esta escama es tres veces mayor que su anchura máxima (Fig. 4.1 c y b) y esta medida cabe 2 3/4 veces en el espacio comprendido desde la base del escafocerito hasta su extremo distal (Fig. 4.1 b y c); la anchura mínima corresponde 4,5 veces a la longitud (Fig. 4.1 a y c) y cuatro veces en la longitud hasta la espina (Fig. 4.1 a y d).



1: longitud total; 2: longitud dorsal, cefalotórax; 3: longitud abdomen; 4: longitud telson; 5: longitud rostro dorsal; 6: longitud cefalotórax sin rostro; 7: longitud ventral del rostro; 8: longitud rostro postocular; 9: longitud lateral del cefalotórax; 10: longitud del escafocerito; 11: longitud, parte media del escafocerito; 12: longitud del segundo par de pereiópodos: a, dactilopodito; a+b, propodito; c, carpopodito; d, meropodito; e, isquiopodito; 13: longitud, 5° par de pereiópodos: a, dactilopodito; b, propodito; c, carpopodito; d, meropodito; e, isquiopodito; 14: diámetro del ojo; 15: longitud, urópodos; 16: altura cefalotórax.

Fig. 2 Esquema de M. acanthurus indicando las medidas tomadas.



1: parte anterior del caparazón al término del surco hepático; 2: término del surco hepático a extremo posterior cefalotórax; 3: espina antenal a espina hepática; 4: ángulo infraorbital al término del surco hepático; 5: final surco hepático a perfil superior caparazón; 6: altura de la región branquial; 7: longitud dorsal primer segmento abdominal; 8: longitud segundo segmento abdominal; 9: longitud tercer segmento abdominal; 10: longitud quinto segmento abdominal; 11: longitud sexto segmento abdominal; 12: longitud telson; 13: longitud de la pleura del segundo segmento abdominal.

Fig. 3 Esquema de M. acanthurus, indicando las medidas tomadas.

3.4 Apéndices torácicos

3.4.1 Tercer maxilípedo Este apéndice es el que muestra menor especialización como parte bucal; relativamente sus artejos son más grandes en los machos, el carpopodito es menor a las 2/3 partes del exopodito y este último es semejante al isquiomeropodito.

3.4.2 Pereiópodos El primer par de pereiópodos de los machos generalmente rebasa la escama antenal con toda la quela o gran parte de ella; en la hembra lo hace sólo con el tercio distal de la quela. El coxopodito presenta un grupo de cerdas en el margen mesial. El basis está provisto de cerdas largas en toda su cara interna y el isquiopodito de las mismas cerdas que el artejo anterior, arregladas en una hilera longitudinal. El meropodito es casi desnudo con algunas cerdas largas en su parte media inferior. El carpus es casi desnudo con un grupo de cerdas en su parte subterminal y cercanas a las del propodus; la longitud del carpopodito es mayor que el doble de la quela y poco menos de 4/3 del merus. En la base del propodus y casi en la articulación con el artejo anterior, la mayoría de individuos presentan seis hileras oblicuas de cerdas plumosas. Los dedos son más largos que la región palmar de la quela, presentando el dactilo generalmente tres grupos de cerdas en la parte externa con variación entre dos y cuatro grupos; la setación del dedo inmóvil es muy variable en el macho y en la hembra existen generalmente cuatro grupos de cerdas en posición laterodorsal, y lateroventral colocadas a la misma altura; el borde cortante de ambos dedos está formado por un reborde medio que se inicia en su tercio proximal y tiende hacia la parte dorsal llegando al extremo y curvándose hacia la parte ventral. En ambos lados del reborde se colocan algunas sedas cortas; la quela termina en un pequeño diente que se inicia en la parte dorsal de los dedos.

El segundo par de pereiópodos tiene el carpo y a veces parte del mero rebasando al escafocerito. El coxo está provisto de un grupo de cerdas colocadas en el ángulo postero interno del artejo. El isquiopodito es mayor en los machos y es casi la mitad de la longitud del merus (Fig. 4.2 e y d) y en las hembras casi tan largo como éste. El merus y el carpus tienen hileras longitudinales de espinas que aumentan de tamaño del margen inferior al superior. El carpopodito es menor que 1,5 veces la longitud del meropodito (Fig. 4.2 c y d); y de 5 a 7 veces más largo que ancho en los machos y de 4 a 5 en las hembras; este mismo artejo es menor que la distancia tomada de la base de la palma a la mitad de los dedos en los ejemplares machos y mayor que la longitud de la quela en los ejemplares hembras.

La quela posee una cubierta densa de pelos en su porción dactilar y termina en un par de dientes que se entrecruzan al cerrarse la pinza (Fig. 4.2). La dentición de estos segundos pereiópodos muestra una gran variación en relación directa con la abundancia de la setación, siendo ésta menor en las hembras. El dedo móvil presenta un promedio de tres dientes, con variación de uno a cinco, colocados sobre un reborde que recorre la parte media del dedo para terminar en el diente distal; las hembras generalmente presentan un solo diente sobre el reborde; el dedo inmóvil al igual que el dactilo tiene un promedio de tres dientes, variando de uno a cinco. El diente más distal del dactilo, generalmente el mayor, es siempre más distal al último diente del dedo móvil. La palma es de cuatro a cinco veces más larga que ancha. Este segundo par está más desarrollado en los machos adultos que en las hembras.

El tercer par de pereiópodos sobrepasa, con el extremo del dactilus, el borde distal de la escama antenal en el macho, en tanto que la hembra generalmente tiene el apéndice más corto que la escama mencionada. El propodus es más corto que el merus y en el macho 2,5 veces más largo que el dactilus y poco más del doble del carpus. En las hembras corresponde al doble.

Los pereiópodos del quinto par llegan casi al extremo de la escama antenal. El propodus es casi el triple de la longitud del dactilo, casi el doble del carpopodito y de la misma longitud del merus; el mismo propodus es un poco mayor en las hembras.

3.5 Abdomen

3.5.1 Descripción El abdomen es liso, sus pleuras presentan cerdas en todo su margen inferior (Fig. 3). Las proporciones de las distintas partes del abdomen son: la longitud del telson (Fig. 3.12) es 1,5 veces la dorsal del sexto segmento (Fig. 3.11) y este último es 1,5 veces la longitud dorsal del quinto segmento (Fig. 3.10); la longitud del primer segmento (Fig. 3.7) es la mitad de la del segundo (Fig. 3.8) y la mitad de la longitud del sexto; la longitud de este último es semejante a la del segundo; la longitud del quinto es menor que la mitad de la longitud del telson.

La longitud dorsal del primer segmento es un tercio de la anchura del abdomen a este nivel; la longitud de la pleura del segundo segmento (Fig. 3.13) es semejante a la anchura abdominal a nivel del tercero; la longitud dorsal del primero es semejante a la anchura máxima del telson.

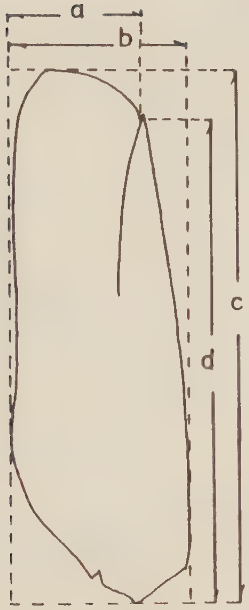


Fig. 4.1 Escama antenal.

a: anchura mínima; b: anchura máxima; c: longitud total; d: longitud hasta la espina.

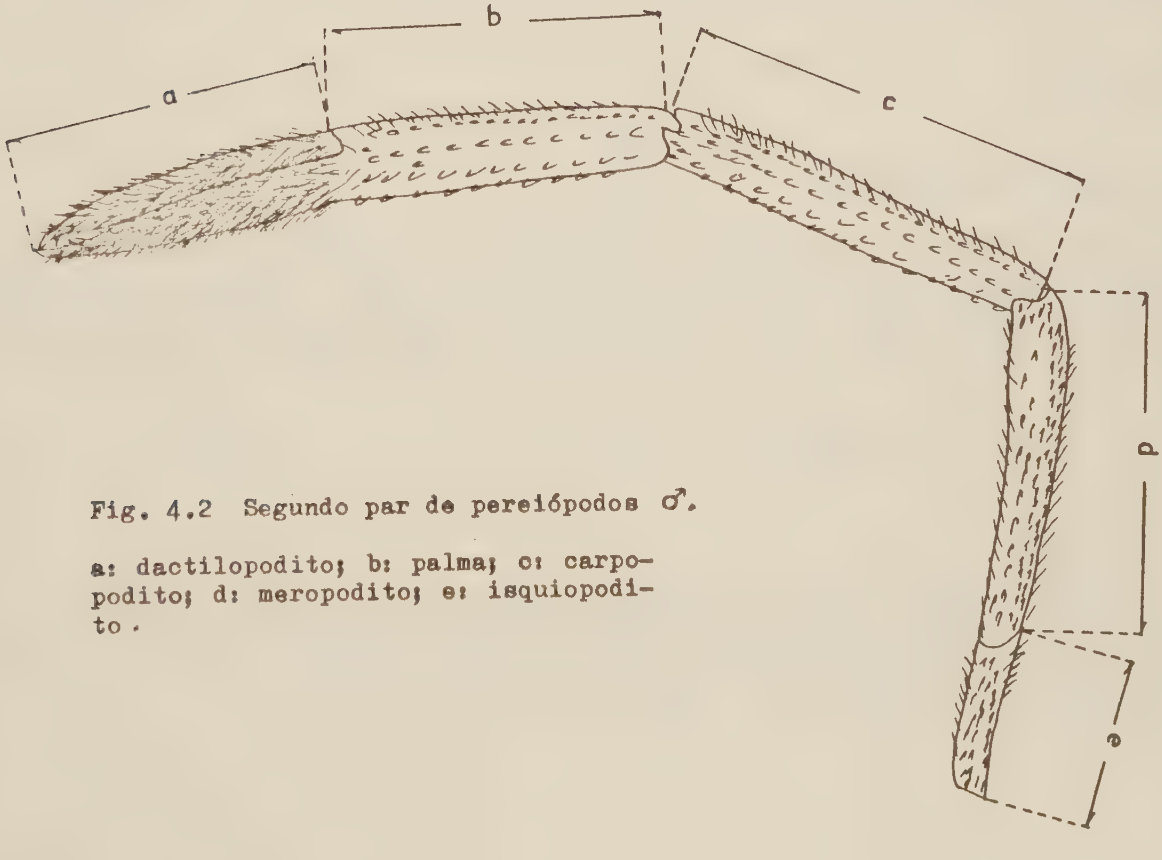


Fig. 4.2 Segundo par de pereiópodos ♂.

a: dactilopodito; b: palma; c: carpopodito; d: meropodito; e: isquiopodito.

Las proporciones arriba citadas son semejantes en la hembra, excepto que la longitud del quinto segmento es igual a su anchura a nivel del mismo segmento y a la mitad de la longitud del telson. Todas las medidas fueron tomadas con el abdomen flexionado.

El ángulo que presenta la pleura del quinto segmento en el macho varía de 76° a 84° con un promedio de 80,5°; en la hembra varía entre 61° y 81° con un promedio de 70°.

Esta parte del cuerpo tiene un ritmo de crecimiento menor que el cefalotórax, pues en los individuos más grandes esta última región es mayor.

3.5.2 Pleópodos El primer par presenta el coxopodito más o menos cilíndrico; el basipodito es de sección triangular y tiene los bordes internos recubiertos por cerdas; en la hembra ovígera se cubren los bordes con cerdas más numerosas y largas. El endopodito es pequeño, plano, alargado y un poco más estrecho en su parte central; se encuentra rodeado de cerdas algo más gruesas en la parte inferior del margen interno. El exopodito es aplanado, largo y está bordeado también por cerdas.

El segundo par es semejante al primero pero presenta el apéndice interno y en los individuos machos el apéndice masculino; el primero se encuentra colocado en el cuarto proximal de la parte interna del endopodito, tiene un aspecto tubular y es un poco más ancho en su tercio distal; se dirige hacia la parte mesial y termina en una superficie cubierta por una serie de proyecciones granulosas (uncinuli) que al entrelazarse con las del artejo homólogo mantienen unidos ambos pleópodos; la longitud del apéndice interno equivale a 1/4 de la longitud del endopodito. El apéndice masculino es un carácter sexual de los individuos machos. Está formado por un segmento plano y espatuliforme, colocado entre el apéndice interno y el endopodito. En la superficie situada hacia el apéndice interno se encuentran varias cerdas largas y rígidas. La longitud de este segmento es el doble de la longitud del apéndice interno.

El resto de los pleópodos es semejante al segundo par con excepción del apéndice masculino.

En la hembra ovígera todas las cerdas de los pleópodos se alargan, excepto en el quinto par, en que continuan en su estado normal.

En los apéndices abdominales se presentan las siguientes relaciones: el basis del primer par, en el macho, es menor que el endopodito del mismo par y es mayor que la mitad del mismo en la hembra; el exopodito es más o menos la mitad de la longitud del mismo artejo en el resto de los pleópodos y generalmente del mismo largo que el apéndice masculino; el basis del quinto es el más corto de los artejos equivalentes en los apéndices abdominales.

En los urópodos la anchura del endopodito es 2,5 veces su longitud en las hembras y un poco menor en los machos.

3.6 Telson

Presenta dos pares de espinas colocados uno a la mitad y el otro a 3/4 distales de la longitud del telson (Fig. 3); muestra un grupo de cerdas en la parte subproximal; termina en un proceso angular con dos pares de espinas de cada lado; las externas son más cortas y las internas sobrepasan dicho proceso; entre estas últimas espinas existen algunas cerdas plumosas más largas que ellas.

4 CONCLUSIONES

En los ejemplares de las cuatro áreas estudiadas se observa una variación marcada en la mayoría de las características morfológicas que se tomaron como base, haciéndose notable la dentición de los segundos pereiópodos, que presentan una relación directa entre el número de los dientes y la abundancia de las sedas, siendo en general menos cerdosas las hembras. Sin embargo, todos los ejemplares se ajustaron en general a las características de Macrobrachium acanthurus.

La variabilidad del rostro es también notable, pues los jóvenes muestran su extremo ligeramente curvado hacia arriba y los adultos lo tienen casi recto, hecho que se aproxima a las observaciones de Holthuis (1952).

El segundo par de pereiópodos varía en su longitud y abundancia de sedas en machos y hembras, siendo más largo en los primeros y proporcionalmente más grueso; sin embargo, algunos machos, a pesar de su estado adulto, presentan estos apéndices poco desarrollados, semejándose por esta característica a las hembras; esos individuos muestran también una escasa setación en estos apéndices.

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OBSERVATIONS ON THE PADDY-FIELD PRAWN FILTRATION OF KERALA, INDIA

by

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Abstract

Experiments were conducted to determine whether culture methods could be advantageously introduced into the existing prawn filtration practices in the paddy fields of Kerala, on the southwest coast of India. The pattern of the fishery is changing, with the demand for small prawns decreasing and that for large prawns increasing. The experiments indicated that culturing of juvenile prawns for about a month resulted in relatively better catches of large sized prawns than could be obtained by cultivation for longer periods. The yield of prawns appeared to be better during the spring tide period associated with the full moon than that associated with the new moon; this is correlated with the increased tidal gradient at full moon. The fishery mainly concerns four species of penaeid prawns, namely, *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis* and *Penaeus indicus*. Recruitment to the fishery is continuous with a peak in March or April. The majority of the juvenile prawns brought into the field by a particular tide do not seem to move out of it when the tide recedes.

E/18

OBSERVATIONS SUR L'ELEVAGE DES CREVETTES DANS LES RIZIERES DE KERALA (INDE)

Résumé

Des expériences ont été faites pour déterminer s'il serait avantageux d'introduire des méthodes d'élevage dans les rizières de Kerala, sur le littoral sud-ouest de l'Inde, où les crevettes sont recueillies par filtration de l'eau. La pêcherie évolue, car la demande de petites crevettes diminue tandis que la préférence va de plus en plus aux grandes.

Des expériences ont prouvé que l'élevage de jeunes durant un mois environ permet de récolter comparativement plus de crevettes de grande taille qu'un élevage étendu sur une période plus longue. La production de crevettes a semblé plus forte durant la vive-eau de pleine lune que pendant celle de nouvelle lune. Il y a corrélation avec l'augmentation du gradient de marée, qui caractérise la pleine lune. La pêcherie exploite actuellement quatre espèces de Pénéidés : Metapenaeus dobsoni, M. monoceros, M. affinis et Penaeus indicus. Le taux de "recrutement" est continu, avec une pointe en mars ou avril. La plupart des jeunes crevettes apportées dans les rizières par la marée semblent y demeurer lors du reflux.

OBSERVACIONES SOBRE LA FILTRACION DE CAMARONES EN LOS ARROZALES DE KERALA, INDIA

Extracto

Se realizaron experimentos para determinar la posibilidad de introducir con éxito métodos de cultivo en los procedimientos actuales de entrada de camarones por filtración en los arrozales de Kerala, en la costa sudoccidental de la India. Están cambiando las características de la pesquería, disminuyendo la demanda de camarones pequeños y aumentando la de camarones grandes. Los experimentos indicaron que el cultivo de camarones juveniles durante un mes aproximadamente, producía relativamente mejores capturas de camarones de tamaño grande que las que se podían obtener por medio de su cultivo durante períodos más largos. Se observó que la obtención de camarones era mejor durante el período de mareas vivas unidas a luna llena, que cuando aquéllas iban asociadas a luna nueva. Esto se atribuye a la mayor altura de las mareas cuando hay luna llena. La pesquería se ocupa principalmente de cuatro especies de camarones peneidos, a saber: Metapenaeus dobsoni, M. monoceros, M. affinis y Penaeus indicus. La pesquería se renueva constantemente, alcanzando el punto máximo de reclutamiento en marzo o abril. La mayoría de los camarones juveniles que penetran en los campos con una marea determinada parece que no los abandonan cuando la marea se retira.

1 INTRODUCTION

Juvenile penaeid prawns are extensively fished from the paddy fields bordering the backwaters and estuaries of Kerala on the southwest coast of India. Nearly 4,500 ha of paddy fields are utilized for this purpose. In the past the huge demand from Rangoon for prawn pulp, locally called "chemmeen parippu", has rendered it a very lucrative fishery. With the advent of the frozen prawn industry in this region, the demand for larger prawns has increased considerably, and the larger sizes from the paddy fields are now sorted out and channelled to the freezers. While the demand from the freezing industry has increased, the prawn pulp trade has decreased, mainly due to developments that have taken place in the countries to which this product was traditionally exported. It has therefore become necessary to find ways of increasing the sizes of prawns caught from the paddy fields, so that a larger proportion of the catches will be suitable for freezing and canning. A few experiments were therefore designed and carried out from 1964 to 1966 to determine whether some sort of culturing could be introduced into the present practice of prawn filtration to promote the growth of juvenile prawns before trapping.

A general account of this fishery has been given by Panikkar (1937), Menon (1954), Gopinath (1956) and Panikkar and Menon (1956). Menon (1954) has also carried out some preliminary experiments to assess the yield from these paddy fields and the rate of growth of two species of prawns. Kesteven and Job (1957) made a preliminary review of the prawn filtration practices of Kerala.

2 THE FISHERY

The prawn fishery is carried out from all the paddy fields lying adjacent to or having connection with the backwaters. The single crop of rice is harvested in September and October, then the paddy fields are leased out for prawn filtration. The size of fields varies from less than 1/2 ha to more than 10 ha. Water from the backwaters is allowed to flow freely in and out of the fields for a few days. The bunds separating the fields are now strengthened and sluice gates fixed, to regulate the flow of water into each field. Normally, each field is provided with one sluice gate which opens into the backwaters. The sluice gate is a rectangular wooden box-like structure, the size of which varies according to the area of the field. Adjustments of wooden shutter planks at the mouth of the sluice regulate the flow of water. During high tide, water is let into the field by opening the shutters, which are closed when the water inside the field reaches the same level as outside. The juvenile prawns enter the fields with the inflow. While letting in water at night, a lamp is hung at the mouth of the sluice. At low tide, water is let out of the field by the same process, but a close bamboo screen is placed at the mouth of the sluice to prevent the prawns from escaping. This process is continued with every high and low tide throughout the fishing season.

Fishing is carried out by fixing a conical sluice net 6 to 7 m in length and with a mesh size of 5 to 12 mm, at the mouth of the sluice by means of a rectangular bamboo frame. At low tide, the shutter planks of the sluice are drawn up, and the water from the field is let out with great force through the net. The prawns collected at the cod end of the net are periodically emptied into a canoe. Special care is taken to see that the water level in the field does not fall too low by replacing the shutter planks of the sluice at the appropriate time.

Generally fishing operations are carried out at night during the spring tide period. Therefore fishing activity is restricted to 7 or 8 nights in a fortnight, i.e. 3 or 4 on either side of the full moon and new moon. The season of the fishery lasts from November to April every year. In April, before the field is handed over to the owner for paddy cultivation final fishing is carried out by completely draining the water from the field in the daytime, using cast and drag nets, and by hand picking. Generally the highest catch is obtained on this day, as the entire prawn population is fished out.

The prawns caught from the fields are mainly penaeids in their juvenile stages, and they comprise Metapenaeus dobsoni (Miers) (thelly chemmeen), M. monoceros (Fabricius) (choodan chemmeen), M. affinis (H. Milne Edwards) (kazhanthan chemmeen), and Penaeus indicus H. Milne Edwards (naaran chemmeen). A few species of palaemonids such as Macrobrachium rude (Heller), M. idae (Heller) and Palaemon styliferus H. Milne Edwards, and the atyid Caridina gracilirostris De Man, are occasionally noticed in the catches, but never in commercial quantitites. Fishes like Mugil spp., Etroplus suratensis, E. maculatus, Ambassis spp., Ophichthys spp., Muraenesox cinereus, Platycephalus sp. and Panchax sp. also occur in the prawn fields, but are caught only on the final day, when the field is completely drained. The portunid crab Scylla serrata (Forskal) occurs in the fields in considerable numbers and occasionally causes damage to the bunds of the fields by burrowing into the mud.

3 EXPERIMENTS IN CULTURING

Field experiments were designed and conducted to study the effects of retaining prawns in the paddy fields for different periods. A paddy field of 3.16 ha, situated about 4 km north of the town of Ernakulam and within the prawn fishing area of the locality, was taken on lease for the studies. The field was surrounded by backwaters on all sides. Extra bunds were provided to divide the field into two large compartments, each having an inside area of 14,400 m^2, and a small compartment of 650 m^2. The two larger compartments were provided with separate wooden sluice gates (438 cm long x 80 cm wide and 215 cm high) to regulate the flow of water to and from the backwater. Of these two compartments, the eastern was used for culture experiments while the western was kept as a control. The small compartment was used for marking experiments using biological stains and could be connected to the culture compartment through a small box sluice. The general depth of water inside the field was about 1 m at high tide and it was never allowed to fall below 1/2 m during any experiment; deeper channels ran across the field from the sluices. The bottom of the field was of soft mud, the depth of which ranged from 20 to 50 cm. The stumps of the rice plants, left after the harvest, decayed and provided a rich supply of organic detritus.

3.1 Design of experiments

Experiment I (February to May 1964) was to determine the growth and mortality resulting from culturing prawns for the entire period of the fishery and to compare the yield with the existing practice of trapping the small prawns. Juvenile prawns were let into both large compartments with the tide every day. While the prawns in the culture compartment were allowed to grow throughout the season, those in the control compartment were fished according to the local practice. The culture compartment was fished at the end of the experiment.

Experiment II (January to May 1965) was similar to the first experiment except that the culture compartment was fished at intervals of one month.

Experiment III (December to May 1966) was designed to compare the productivity of the experimental field with that of other prawn fields in the neighbourhood, and to compare yields from the two large compartments when fished according to local practice.

In all these experiments regular samples of prawns were taken from both compartments for recording their composition and size. When the experiment did not permit use of the sluice net in the culture compartment, samples were obtained with a cast net having the same mesh-size as that of the sluice net.

3.2 Hydrology

Surface salinity and temperature of the backwater near the experimental prawn field were recorded throughout the period from February 1964 to May 1966. These features were also recorded from inside the field during the periods of the experiments; the temperature was noted twice daily, at 0900 and 1500, and the salinity was estimated on alternate days.

The difference in water temperature between the backwater and the field was highest at the end of February. The generally lower temperature inside the field may have resulted from evaporation.

3.2.1 Salinity The fluctuations in salinity are shown in Fig. 1. As noticed by George (1958), Balakrishnan (1957) and George and Kartha (1963), the salinity of the backwater shows wide fluctuations, the pattern of which is the same each year. The water is almost fresh (salinity falling below 1.0°/oo) during the monsoon months of July and August, then the salinity rises to more than 30.0°/oo by early April and maintains this high level until June.

During the experiments, the water inside the field remained more saline than that of the outside backwater. This was probably due to evaporation in the confined area.

3.2.2 Temperature As in the case of salinity, temperature also shows a minimum in the monsoon months of July and August, and increases thereafter (Fig. 1). Invariably the evening temperature was found to be higher than that of the morning. The range of temperature in the backwater was between 22.9 and 33.0°C.

During the experiments, the mean temperature inside the field was found to be slightly lower than that of the surrounding water, except in January and May. These were also the two months in which the range of temperature in the field was smallest.

3.3 Results

The details of catches obtained from the culture and control compartments of the field are shown in Table I.

TABLE I

Total catches of prawns from the culture and control compartments for three seasons

Year	Catch in kg		
	Culture Compartment	Control Compartment	Total
1964	155	854	1,009
1965	787	966	1,753
1966	786	874	1,660

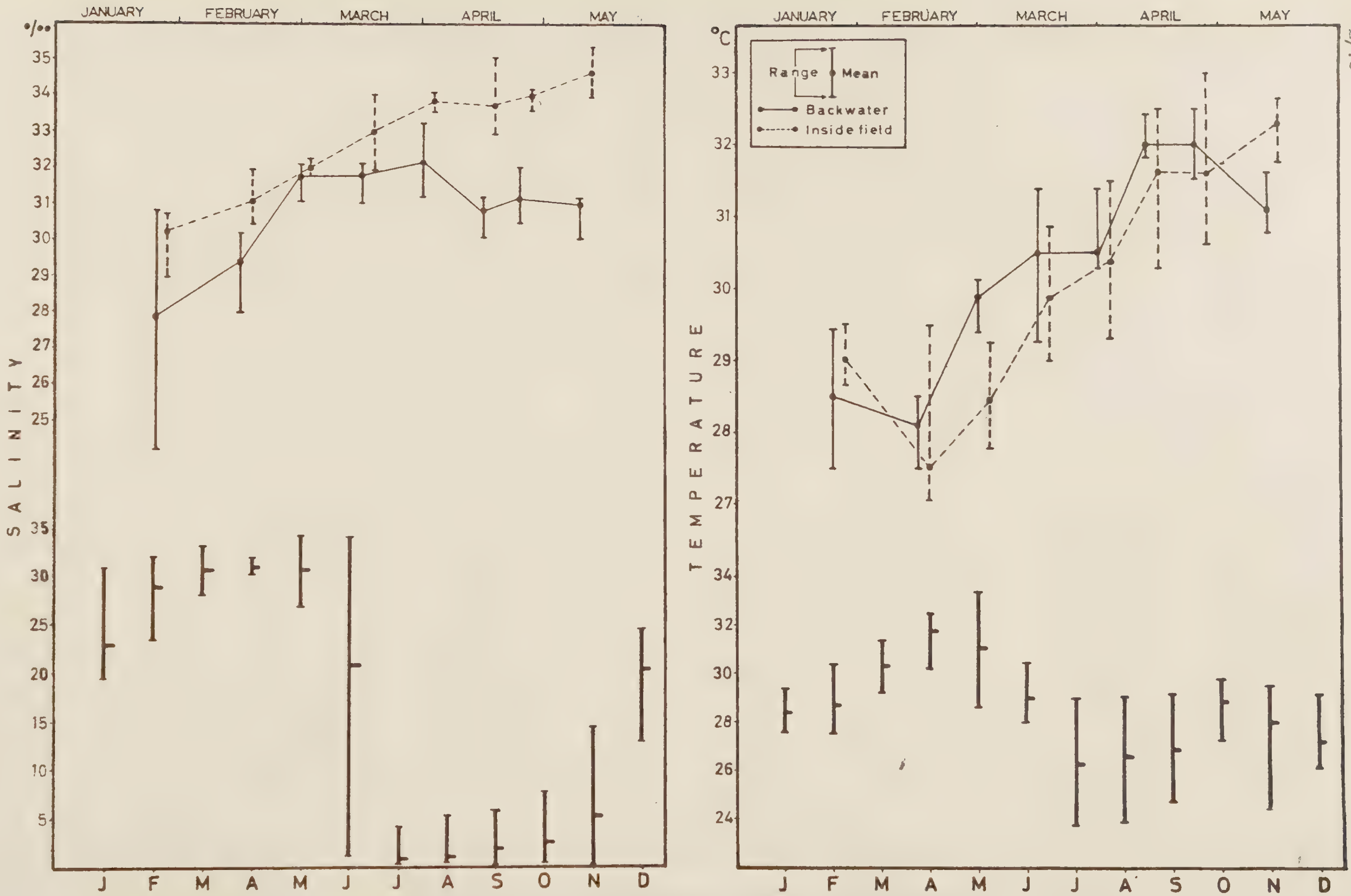

Fig. 1 Surface salinity (left) and temperature (right) in the experimental field and adjacent backwater. The lower part of each diagram shows the monthly range and mean for the backwater for the period February 1964 to May 1966; the upper part shows values for the field and the backwater for the months when experiments were in progress.

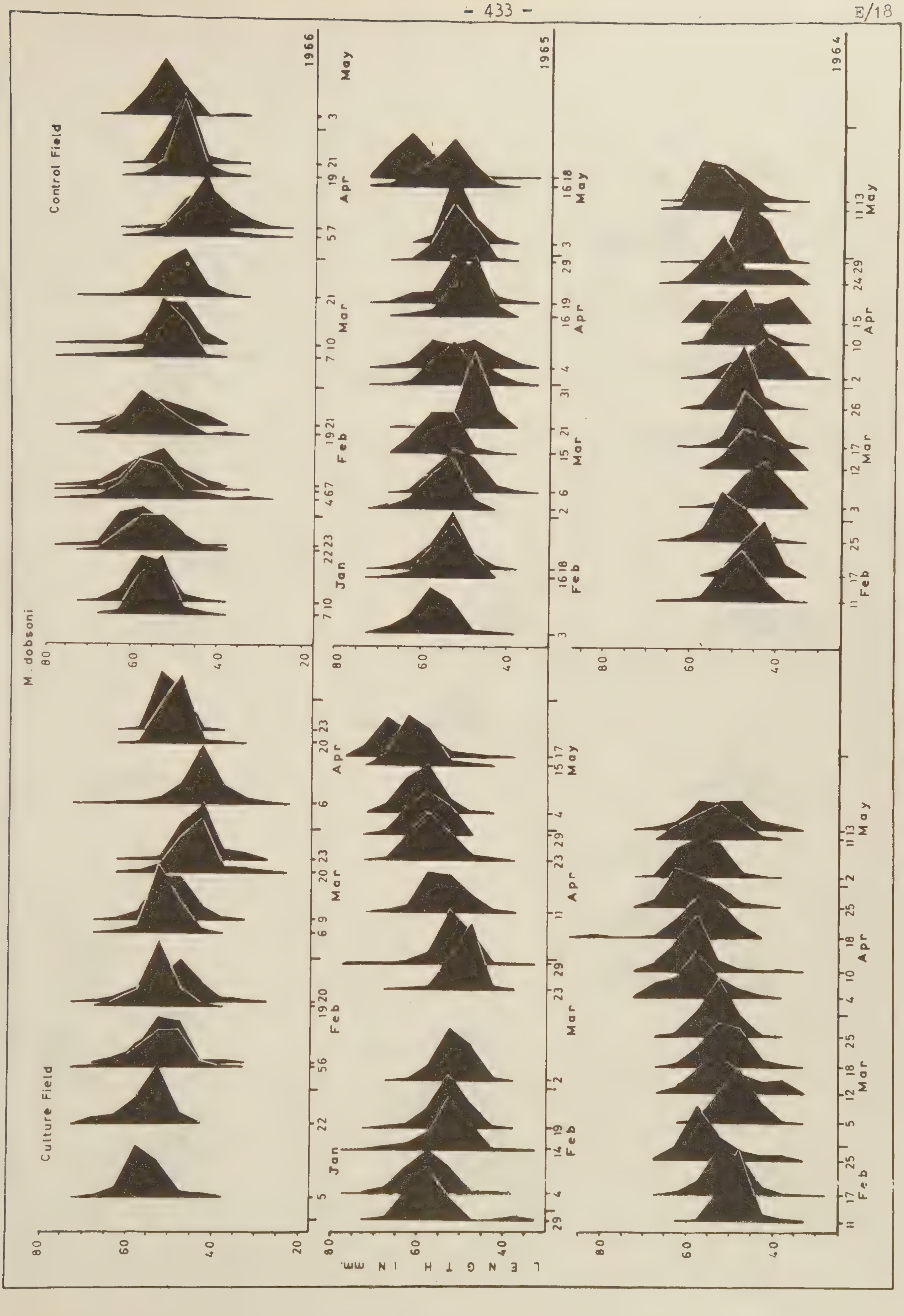

Fig. 2 Length-frequency distribution of Metapenaeus dobsoni in the culture and control compartments, 1964 to 1966.

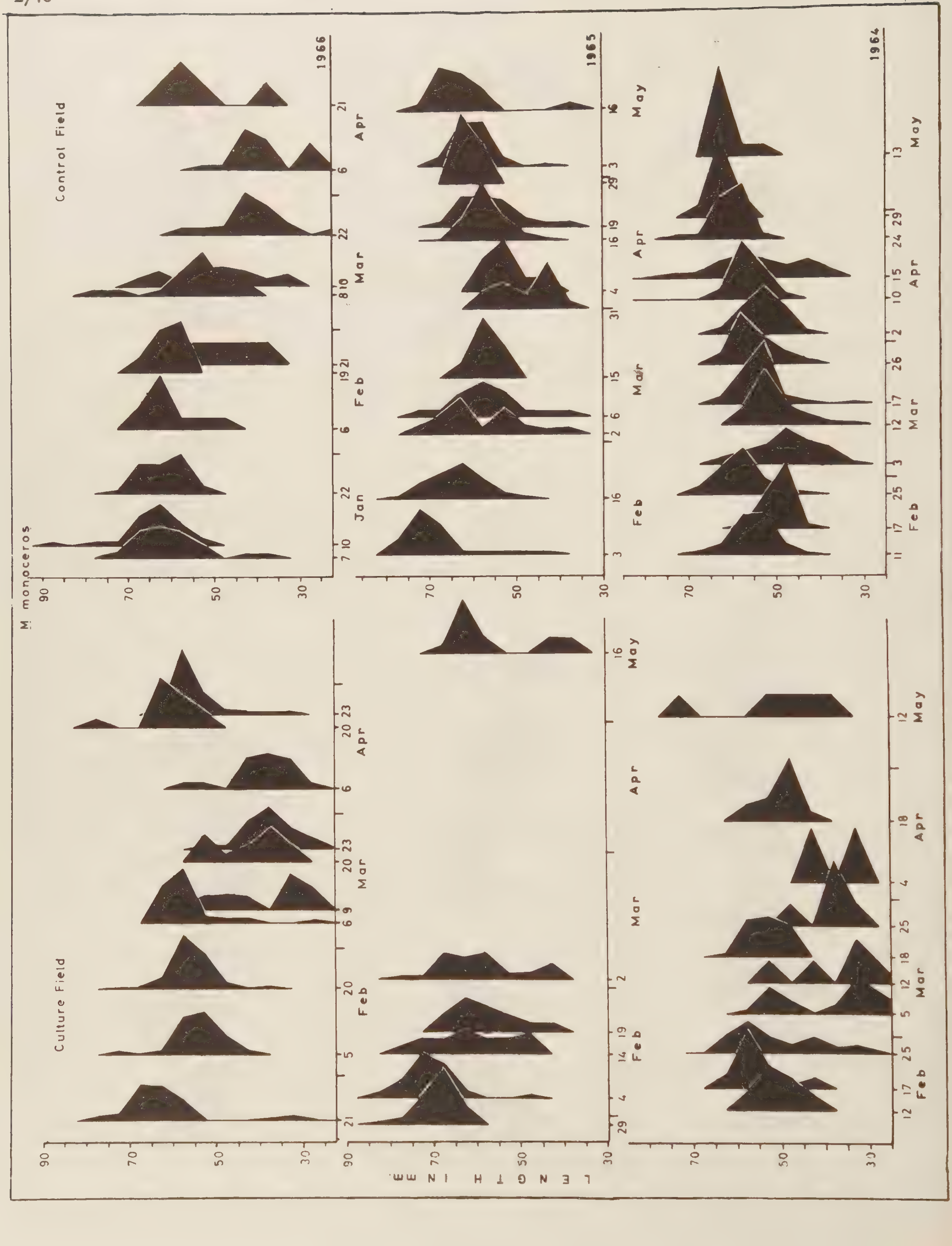

Fig. 3 Length-frequency distribution of Metapenaeus monoceros in the culture and control compartments, 1964 to 1966.

The catch from the culture compartment was extremely poor in the first experiment, when the prawns were allowed to grow inside this compartment for four months before fishing. This was a surprise, as the physical conditions affecting the two compartments remained identical and the chances of entry of young prawns were the same, as similar procedures were followed for letting water into both compartments. Cast net samples showed that, during the initial stages of the experiment, large number of prawns were present in the culture compartment. The rather insignificant catch obtained from the culture field at the end of the experiment could only be due to mortality, probably brought about by overcrowding. The distribution of length-frequency of the different species of prawns obtained from culture and control compartments is shown in Figs. 2 to 5.

In the second experiment, when fishing in the culture compartment was carried out at monthly intervals, the catches were much better. The differences in the pattern of size distribution of prawns from the culture and control compartments were less marked than in the first experiment.

In the third experiment in which there was no attempt to culture prawns in either compartment, a higher return was again obtained from the control compartment. The yield from the compartment which had previously been used for culturing was the same as in the previous experiment (Table I). The patterns of size-distribution of the prawns caught from the two compartments in this experiment were identical, as was expected (Figs. 2 to 5).

The catches from the control compartment were uniformly better in all three years. This could probably be attributed to the topography of the field and the nature and depth of the backwater into which the sluice gates of the compartments opened.

The productivity of the whole field in relation to some of the fields in the neighbourhood, and the success or failure of the operations of these three years, may be judged from Table II. The first year's experiment no doubt reduced the overall prawn catch from the field but in the subsequent two years the yield realized was rather better than that of the adjacent fields. Menon (1954) obtained a maximum of 9.62 kg prawns per day per ha from a field at Narakkal, about 10 km north of the present field. It is therefore clear that the field had no inherent defect that would influence the results of the experiments.

TABLE II

Comparison of catches of other fields

Field	Year	Area (ha)	No. of days fished	Total catch (kg)	Catch per day (kg)	Catch per day per ha (kg)
Experimental field	1964	3.16	42	1,009	24.0	7.6
"	1965	"	49	1,753	35.8	11.3
"	1966	"	42	1,660	39.5	12.5
Neighbouring field 1/	1965 -66	5.56	61	3,746	61.4	11.0
" 2/	"	3.23	48	1,532	31.9	9.9

1/ Result of commercial operations in a field situated 1 km west of experimental field

2/ Result of commercial operations in a field situated 6 km northeast of experimental field

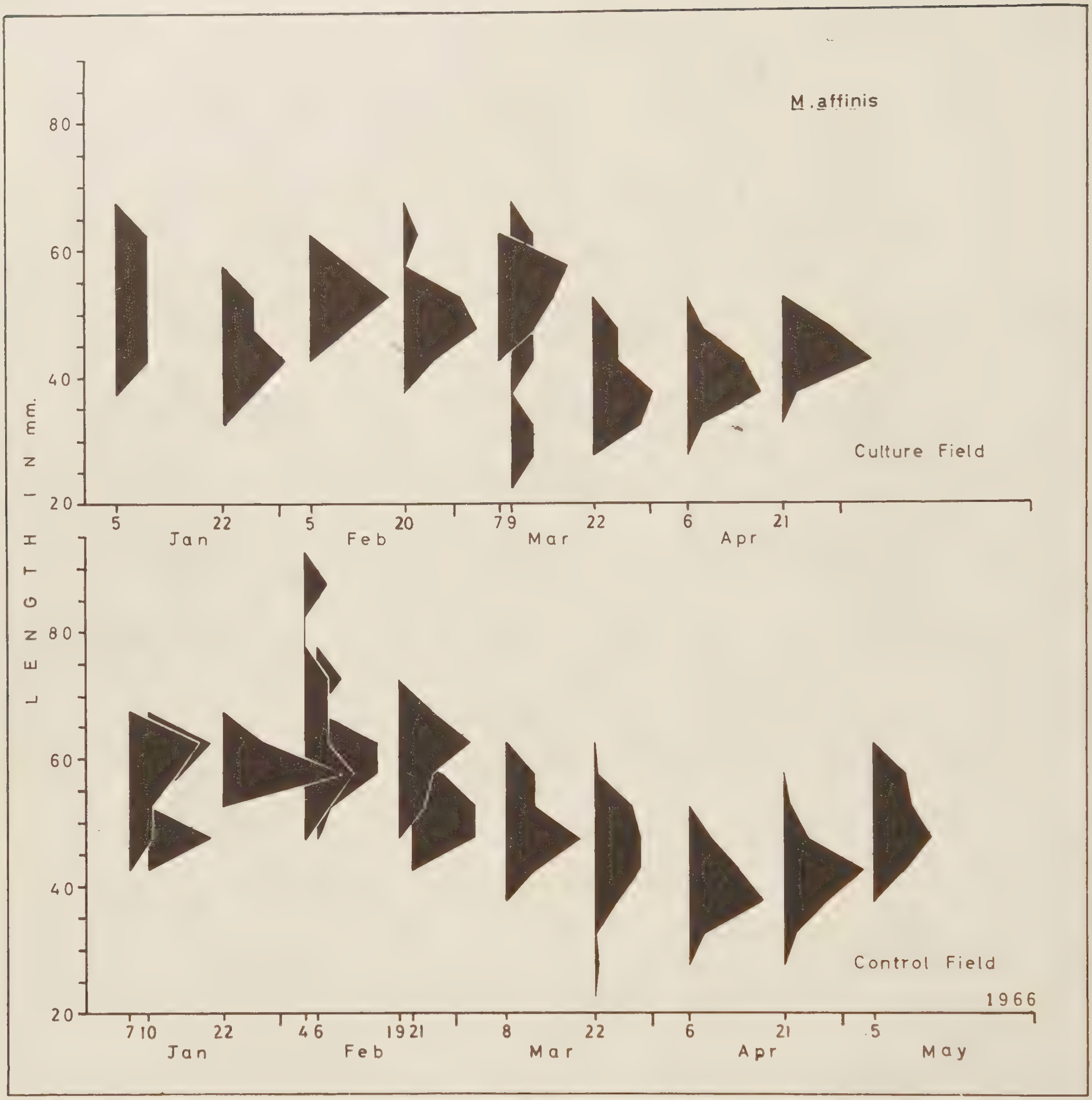

Fig. 4 Length-frequency distribution of Metapenaeus affinis in the culture and control compartments, 1966.

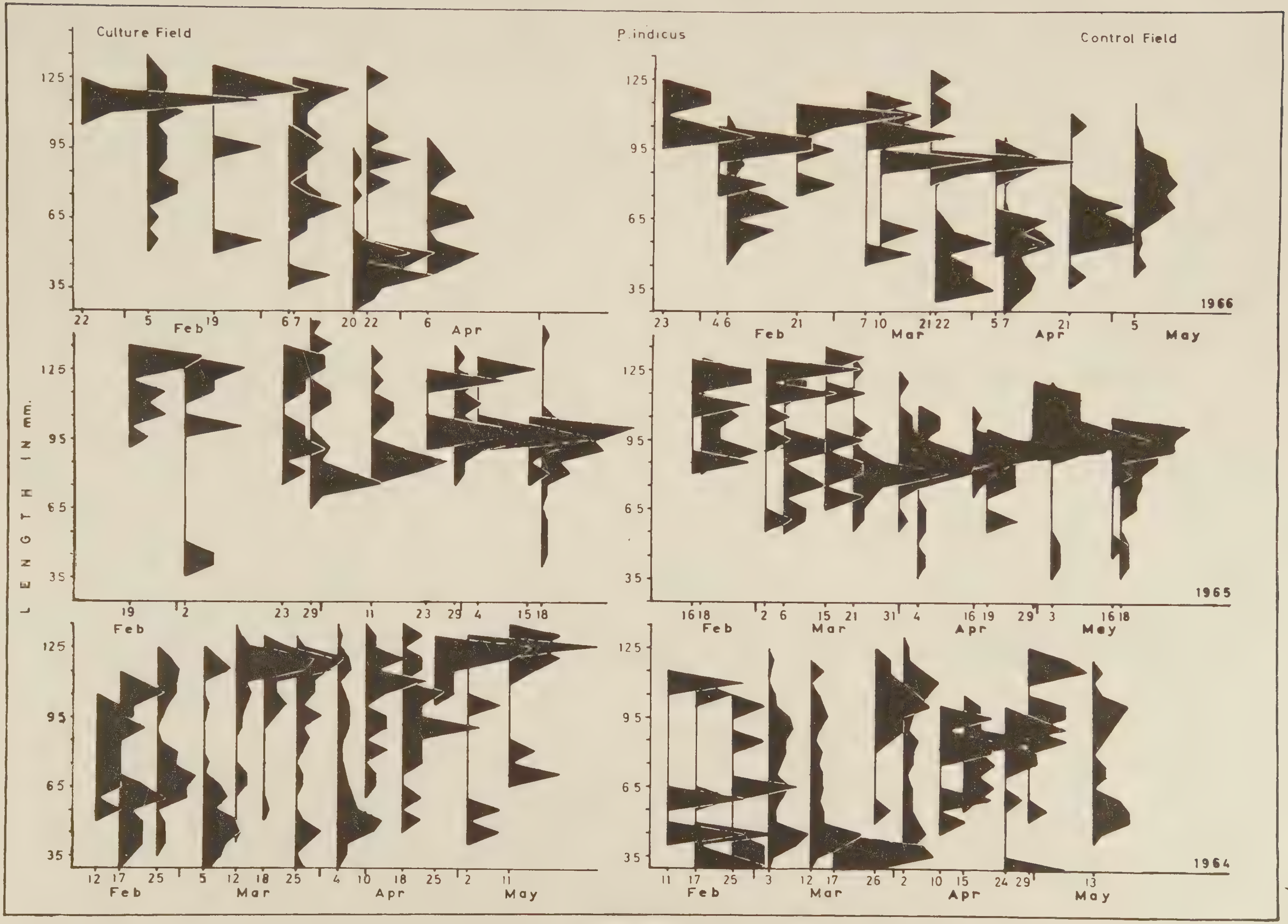

Fig. 5 Length-frequency distribution of *Penaeus indicus* in the culture and control compartments, 1964 to 1966 .

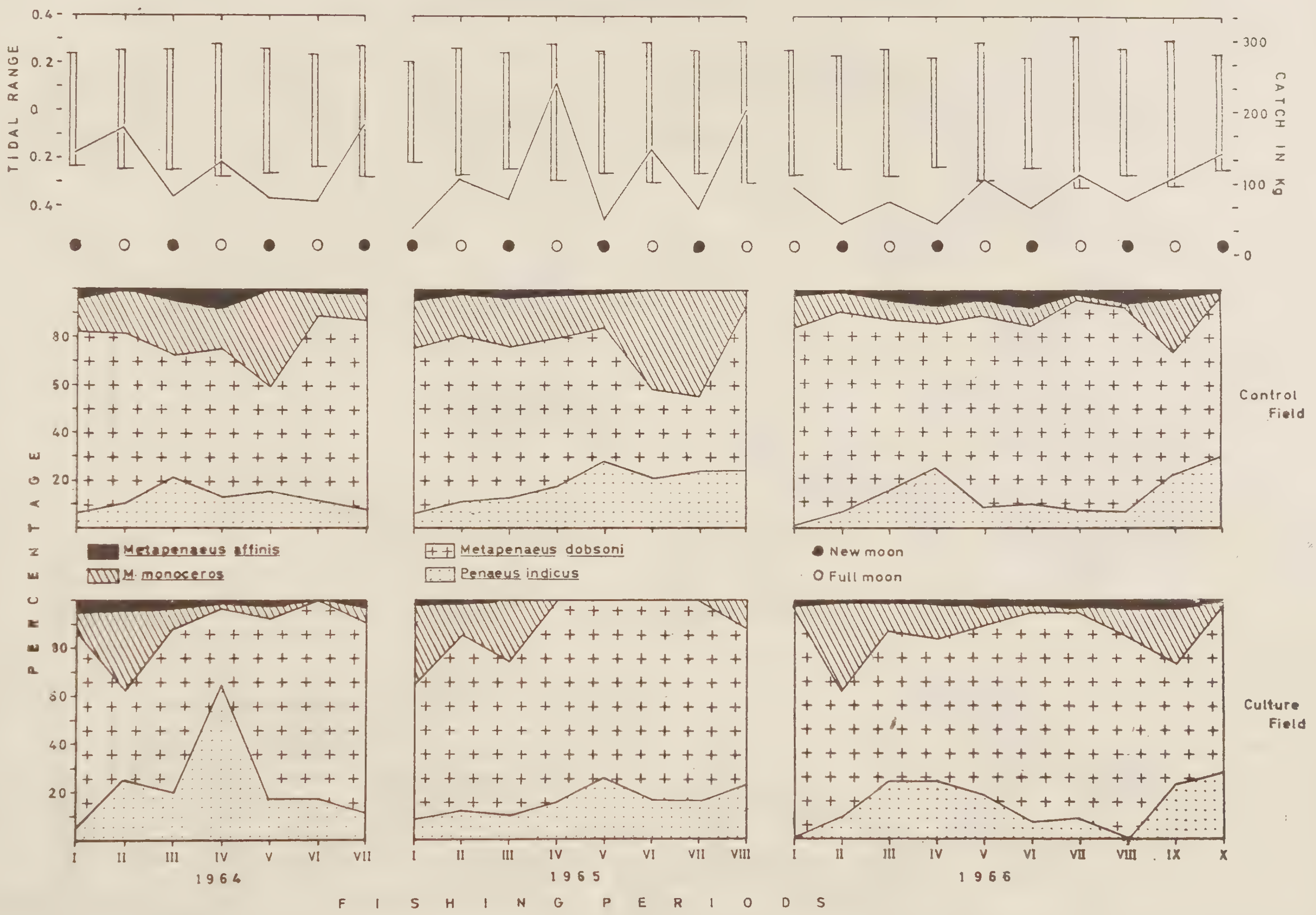

Fig. 6 Upper: fortnightly catch with phase of moon and tidal range, during experiments in each year, 1964 to 1966
Lower: percentage of each species in catches during experiments in each year, 1964 to 1966. Each experiment is divided into fortnightly periods.

A perusal of these results indicates that culturing of prawns for long periods in paddy fields generally does not result in an increase in the weight of the catches. On the other hand, culturing for periods of about one month, as in experiment II, is likely to bring in better catches containing larger prawns.

4 COMPOSITION AND FLUCTUATION OF CATCHES

The percentage composition of catches from control and culture compartments at fortnightly intervals is shown in Fig. 6. Of the four species of penaeids represented, M. dobsoni was by far the most important, accounting for more than 50 percent of the catch in most samples. M. monoceros and P. indicus each averaged about 20 percent of the catch, but showed considerable variation within each set of experiments and from year to year. M. affinis was represented in the catches by only very small numbers. In both 1964 and 1965, the years in which culturing took place, M. monoceros was scarce in the culture compartment in the second half of each experiment although it was plentiful in the control compartment. It may be that certain physical, chemical or biological conditions that are prevalent in the culture field towards the latter half of the season affect this species adversely. Such a suggestion, however, conflicts with the general impression that this is the hardiest of the four species of prawns.

5 FACTORS AFFECTING CATCHES

That the phases of the moon may exert considerable influence over fishing conditions in respect of many a fishery is well known (Wheeler, 1937; Rounsefell and Everhart, 1953; Jayaraman et al, 1959; Racek, 1959). This is particularly so in the paddy field prawn fishery of Kerala, where the neap tide period is observed to yield such low catches as to render it unremunerative to carry out fishing operations. Consequently this fishery is active during the spring tide period only. Catches obtained from the control compartment during the present work are of interest in this context. Catches from the culture compartment are not considered since it was not fished throughout the season.

The trend of yield in relation to lunar phases, as shown in Fig. 6, indicates that the catches are invariably higher at the spring tide associated with full moon than those at the corresponding tide of the new moon period. This pattern is clearly repeated each year and is equally apparent in the overall catches of prawns as well as in the occurrence of all the constituent species. The effect is less apparent in the last catch of each season, but this is not strictly comparable with the other catches as the field is completely fished out by cast netting, hand picking, etc.

Menon and Raman (1961) observed higher catches at new and full moon and a couple of days following each, but did not notice any variation in catches between the darker and brighter phases of the moon in the stake net fishery of Cochin backwaters. Subramanyam (1965) recorded relatively better catches of prawns during the darker fortnights in the stake net fishery of the Godavari estuarine system on the east coast of India. The present observations, however, do not seem to be in agreement with this record, as in all the three seasons a comparatively better yield of prawns was realized during the brighter phase of the moon. The obvious physical characteristic of this phase of the moon is the amount of light, and the role of this as a factor influencing the behaviour of prawns has been discounted by Racek (1959), as a result of laboratory experiments. It is well known that the phases of moon influence the height of the tide. The prawn filtration practice under study is mainly dependent on tidal flow, therefore some relationship between the yield and the factor responsible for increased tidal flow is to be expected. The average tidal gradient for each of the periods of fishing is given, with the corresponding catches in Fig. 6. From this it appears that the higher catches noticed in each brighter fortnight were really brought about by the increased tidal gradient and the resultant increased rate of flow from the prawn field.

When the day to day fluctuations of catches are examined in relation to salinity and temperature, no significant correlation is evident.

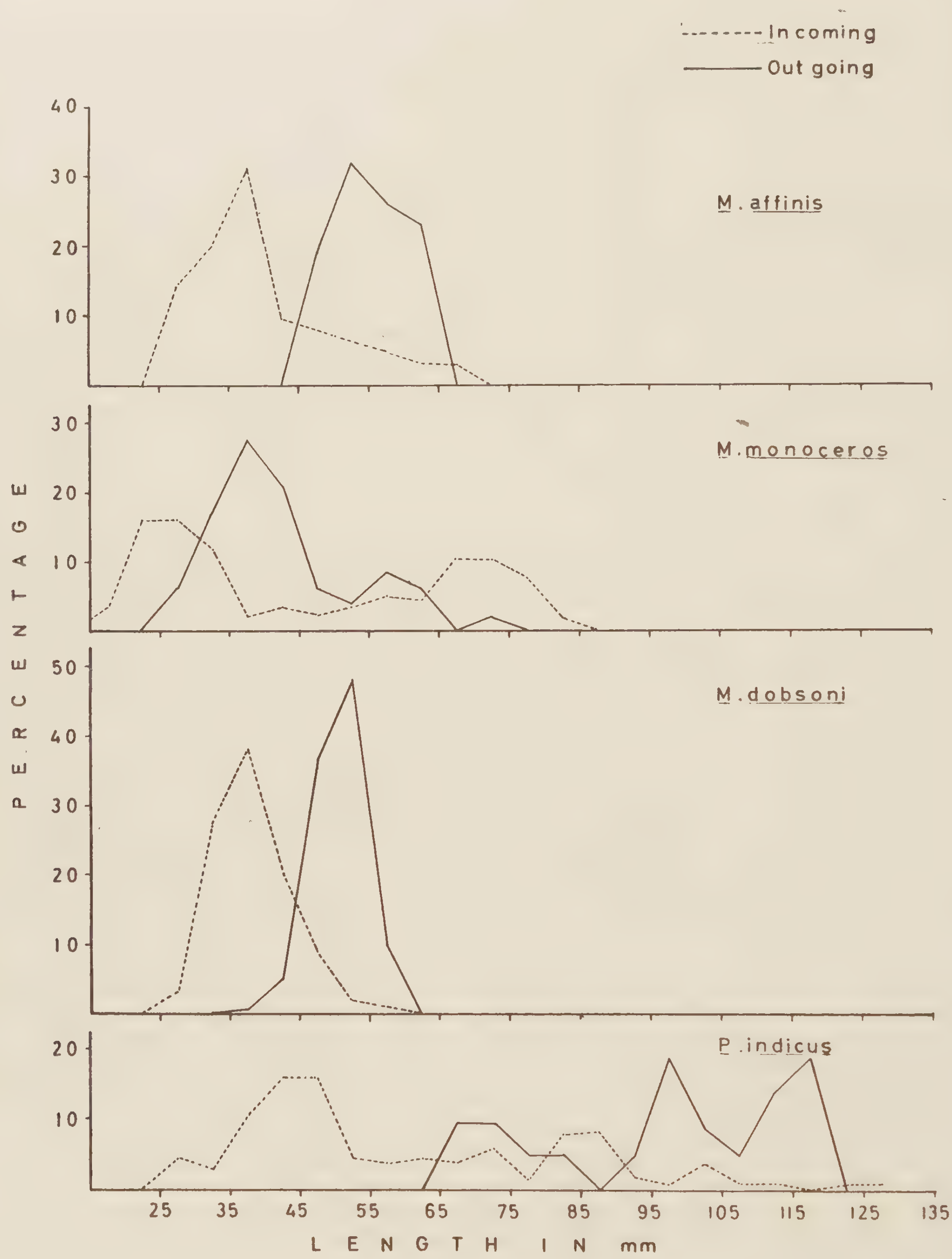

Fig. 7 Length frequency distribution of incoming and outgoing prawns.

6 RECRUITMENT TO THE FISHERY

A perusal of the size frequency polygons shows that the recruitment to the fishery in the case of all the species is more or less continuous, with the smaller size-groups most prominent in the months of February, March and April. These recruits to the paddy field fishery probably come from the peak spawning in November and December.

The fishery is generally described as a mere process of trapping juvenile penaeids allowed into the paddy fields along with the tide and captured at the favourable low tide. (Panikkar, 1937; Menon, 1954; Gopinath, 1956; Kesteven and Job, 1957) In this context Kesteven and Job state ".... during the interval of a few hours or days that the trapped shrimps remain in the fields they utilize the food organisms within the field and those brought by the tidal water". It would therefore appear that the prawns remain in the field only for a very short period. During the present study some experiments were conducted to find out whether these prawns are passively transported in and out of the field by the flow of tide or whether they remain inside the field for any length of time. Collections of 15 min duration were obtained using the same sluice net when the tide was flowing into the field and a few hours later when it was flowing out. The average size distribution of the prawns obtained during these operations is shown in Fig. 7. The modal sizes of the incoming and outgoing prawns were widely separated for each of the four species. The majority of the recruits brought into the field by the incoming tide therefore, do not seem to move out during the subsequent outgoing tide. In all the Metapenaeus species this disparity in the modal sizes of the incoming and outgoing prawns is 15 mm, and in the case of P. indicus the modal sizes are separated by 20 mm. Such size differences probably represent 5 or 6 weeks growth. It is suggested that the incoming small prawns seek shelter before the flow of tide reverses. It is quite possible that the incoming prawns get buried in the mud and settle down in the new habitat for some time. Therefore it would follow that these paddy fields are not merely a part of the trapping mechanism but that they also provide an active and suitable biological environment for the life and growth of these prawns.

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STOCK ASSESSMENT IN THE SHRIMP (*Heterocarpus reedi*) FISHERY OF CHILE

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Abstract

A review has been made of the available information relative to a stock assessment of the shrimp fishery of Chile. Exploratory surveys have shown that some lightly exploited stocks of *Heterocarpus reedi* still exist. A careful analysis of existing data on catch and effort shows the catch per trip to be variable, but there is an indication of fewer, but longer trips each month. The average catch per trip increased between 1965 and 1966. The analysis is complicated by the heterogeneity of the fleet, and the use of the same vessels for other species, primarily langostino, and so far there has been no reliable information on the length of trips. There was no detectable difference between size compositions in 1958-59 and 1965-66. Male shrimps generally constituted well under half of the catch, and the majority of females were ovigerous during the winter months. The highest recorded annual catch of shrimps was for 1966 and the evidence suggests that the landings may continue to increase.

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PECHERIES CHILIENNES DE LA CREVETTE Heterocarpus reedi: EVALUATION DES STOCKS

Résumé

On a passé en revue les renseignements disponibles permettant de procéder à une évaluation des stocks des pêcheries chiliennes de crevettes. Des campagnes de prospection ont révélé qui'il existe encore des stocks de Heterocarpus reedi peu exploités. Après examen attentif des données existantes sur les captures et l'effort de pêche, on constate une variabilité de la prise par sortie, mais il semble que les voyages mensuels se fassent moins nombreux et plus longs. La prise moyenne par sortie a augmenté de 1965 à 1966. L'étude est compliquée par l'hétérogénéité de la flotte, ainsi que par l'utilisation des mêmes navires pour la pêche d'autres espèces, notamment le "langostino"; en outre, on ne dispose pas jusqu'ici de renseignements sûrs concernant la durée des voyages. On n'a pas décelé de différences dans la composition par tailles entre 1958-59 et 1965-66. Dans l'ensemble la proportion des mâles dans les captures est loin d'atteindre 50 pour cent, et la plupart des femelles sont ovigères durant les mois d'hiver. C'est en 1966 qu'a été enregistrée la plus forte prise annuelle, et tout porte à croire que les mises à terre pourront continuer à progresser.

EVALUACION DE POBLACIONES EN LA PESQUERIA DE CAMARONES (Heterocarpus reedi) DE CHILE

Extracto

Se ha realizado un estudio de la información disponible relativa a la evaluación de las poblaciones de la pesquería camaronera chilena. Los estudios exploratorios han mostrado que todavía existen algunas poblaciones poco explotadas de Heterocarpus reedi. Un análisis cuidadoso de los datos existentes sobre captura y esfuerzo, muestra que la captura por viaje es muy variable, pero existen indicaciones de que se realizaron menos viajes, pero más largos, cada mes. La captura media por viaje aumentó entre 1965 y 1966. Complica el análisis la heterogeneidad de la flota y el empleo de los mismos barcos para otras especies, principalmente langostinos, y hasta ahora no se ha dispuesto de información fidedigna acerca de la duración de los viajes. No hubo diferencia apreciable entre las composiciones por tamaño en 1958-59 y 1965-66. Los camarones macho constituyen en general bastante menos de la mitad de la captura, siendo ovígeras la mayoría de las hembras durante los meses de invierno. La mayor captura anual de camarones registrada correspondió a 1966, y la experiencia indica que es posible que continúen aumentando las cantidades que se desembarcan.

1 INTRODUCTION

In 1954, Lindner (1957) examined the shrimp fishery of Chile and concluded that production was very small, amounting to only about 100 t, including heads. By 1966, the shrimp fishery had increased to more than 10,000 t. In addition, landings of "langostino" had increased from 2,600 t in 1954 to over 11,000 t in 1966 (Fig. 2).

The species of shrimp of potential importance in Chilean waters (Mistakidis and Henríquez, 1966) are three:

a) Rhynchocinetes typus H. Milne Edwards, the "camarón de playa". A small to medium sized shrimp of the family Rhynchocinetidae which is fished close inshore with small traps, and, before 1953, comprised most of the landings of shrimps.

b) Heterocarpus reedi Bahamonde, the "camarón nailon". A pandalid shrimp which accounts for about 95 percent of present landings. Mistakidis and Henríquez (1966) recorded that the deep-sea fishery for this species commenced in 1953, when boats trawling for hake in depths of 180 m encountered concentrations first of langostino, and later of H. reedi, which is now fished in depths of more than 200 m.

c) Hymenopenaeus diomedeae (Faxon), the "gamba", is a penaeid shrimp, larger than the other two species, which is trawled in depths beyond the 150 fm (275 m) line. Although there have been reputed catches approaching 1 t per h, there have been no commercial developments involving this species.

Langostino species must also be mentioned since they are often caught with shrimps, thus creating problems in the analysis of catch and effort data. In Chile the name is used for species of Galatheidae, Cervimunida johni Porter, the "langostino amarillo", and Pleuroncodes monodon (H. Milne Edwards), the "langostino colorado", the first of which is the more important. Langostino are normally fished in depths from 100 to 250 m.

Biological and economic studies on the shrimp and langostino fisheries commenced at the Instituto de Fomento Pesquero (IFOP) in January 1965, and reports have been presented on exploratory surveys (Mistakidis and Henríquez, 1966; and unpublished work) on stock assessment (Saetersdal, Henríquez and Sanhueza, MS), and on industrial aspects of the fishery, processing and marketing (López-Capont et al., 1965). Before 1965, information on Chilean shrimps was limited to the biological and taxonomic publications of Bahamonde (1955; 1958; 1963) and of Bahamonde and López (1960), a general account of the shrimp fishery by Lindner (1957) and statistics of landings collected by the Department of Fish and Game of the Ministry of Agriculture.

The aim of the present paper is to review the existing information, and to discuss ways of improving the collection of data necessary for a stock assessment of the shrimp fishery.

2 THE FISHERY

The most important landing ports, for both shrimps and langostino, are Valparaíso, San Antonio, Quintero and Coquimbo (Figs. 1 and 3). At Valparaíso, which is responsible for more than half of the country's landings, there are five companies which in 1966 operated a fleet of 16 boats (Table I), of extremely diverse size, age and construction, working principally for shrimp and/or langostino. There were a further 20 boats working from the remaining ports; these have almost all been modified for trawling from some other purpose, and range from 38 ton wooden purse seiners to a 280 ton steel-hulled whaler (Table I). At Quintero there is a small fleet of German trawlers.

The species receiving the major effort may depend on a variety of factors including its availability, the demand (especially for shrimps) and the incidence of moulting (langostino). The by-catch usually includes hake (merluza) and occasionally the same boats will concentrate on trawling for this species. This was one reason for the poor shrimp landings during 1963 (Fig. 2).

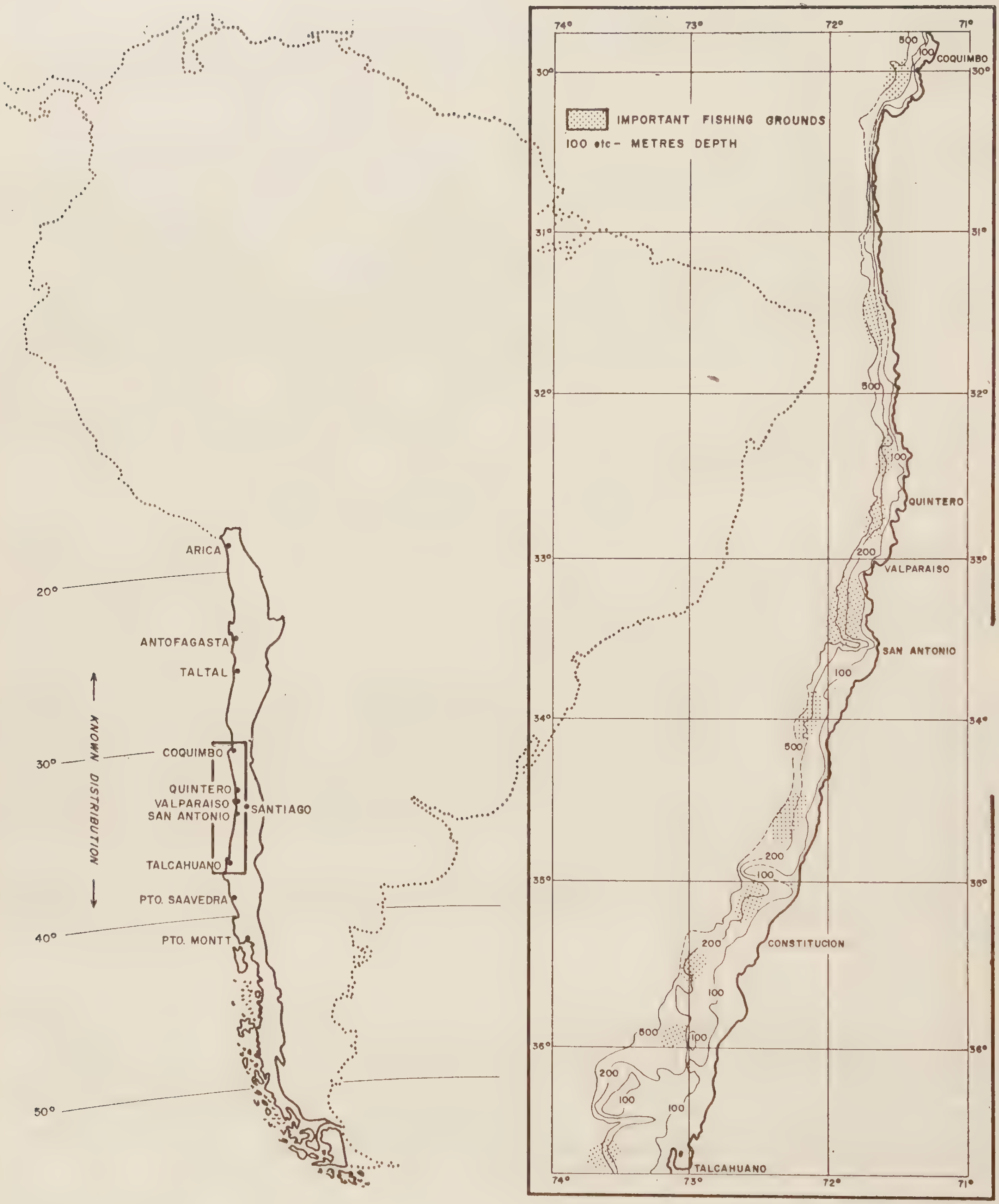

Fig. 1 Distribution and main fishing grounds for Heterocarpus reedi.

Shrimp and langostino may be taken together in the same hauls, but, since shrimps are usually found in deeper waters than langostino, fishing is likely to be directed towards one species or the other (Figs. 13 and 14). The best grounds for shrimps and langostino are from Coquimbo to Valparaíso and off San Antonio and Constitución (Fig. 1), roughly between 29 and 35°S. In these areas boats may expect to take up to 1,600 kg/h of shrimp or 2,000 kg/h of langostino. Mistakidis and Henríquez (1966), aboard a commercial boat in March 1965, observed smaller catches at night, and suggested this was because the shrimps were off the bottom at that time.

Shrimps are normally taken on a bottom of muddy sand, clay or compacted clay, while langostino are generally confined to areas of sand and muddy sand with less clay. The gear for both species therefore does not normally need to be designed for very rough bottoms.

The normal gear is an otter trawl, modified from a German fish trawl, with heavy doors, each weighing about 350 kg, depending on the size of vessel and made from iron or iron and wood. A typical net is made of nylon or polypropylene, with a 95 ft (29 m) footrope, 81 ft (25 m) headline, and a stretched mesh of about 4 cm for shrimps and 5 cm for langostino. The net for one species is frequently not changed when fishing for the other, and there are no regulations covering the mesh of nets. Regulations do exist specifying a minimum size (2.5 cm carapace length), a close season (1 September - 31 December) and the prohibition of landing of berried females, but in no case is the species of marine shrimp specified.

The majority of boats are at sea for less than 24 h, and none are away from port for more than 3 days. This is due partly to the limited range of the smaller boats and partly to the lack of refrigeration facilities. With present conditions of storage on ice, spoilage will occur rapidly after 3 days. Only a small proportion of landed shrimps and langostino are consumed fresh; the remainder are cooked on shore at the processing plants, either by boiling or under steam, and usually peeled by hand. Hand peeling is often stipulated by overseas buyers. The average yield of cooked flesh per total weight landed is about 17-18 percent for shrimps compared with 8-9 percent for langostino.

A large fraction of the cooked shrimp is frozen while the remainder (less than 10 percent) is canned. A very high proportion of the total landings of both species is exported, and the value of exports has risen steadily during the past few years. By 1965, the total export of shrimps, mostly frozen, many of them for the United Kingdom, reached a value of US $1.25 million. Langostino exports reached a total value of $1.75 million in 1965, mostly frozen for the United States.

During 1966, more processing plant has been added, some of it with modern equipment, and total landings of shrimps showed a marked increase in that year (Fig. 2). The value of exports for 1966 totalled US $4.6 million, which included US $2.6 million of shrimps.

3 DISTRIBUTION AND EXPLORATORY FISHING

Heterocarpus reedi has so far not been identified anywhere farther north than Taltal nor farther south than Puerto Saavedra (Fig. 1), but information is still lacking on its complete distribution. It is similar in appearance to H. hostilis Faxon, which was taken between Panamá and the Galápagos Islands, but it is more like H. dorsalis Bate which is not found in the eastern Pacific. The three species differ in a number of characteristics (Bahamonde, 1955).

Neither shrimps nor langostinos have been encountered in commercial densities in Chile north of Coquimbo, but to the south good catches have been reported by boats trawling for hake off Talcahuano (Fig. 1). In view of the increasing demand for frozen shrimp and langostino, the Chilean Development Corporation (CORFO) arranged the first exploratory survey of this area in April 1964. The relatively few hauls which yielded good catches contained up to 1,300 kg/h of shrimps and 1,700 kg/h of langostino (Mistakidis and Henríquez, 1966) and were sufficiently encouraging for more observations to be made in the area.

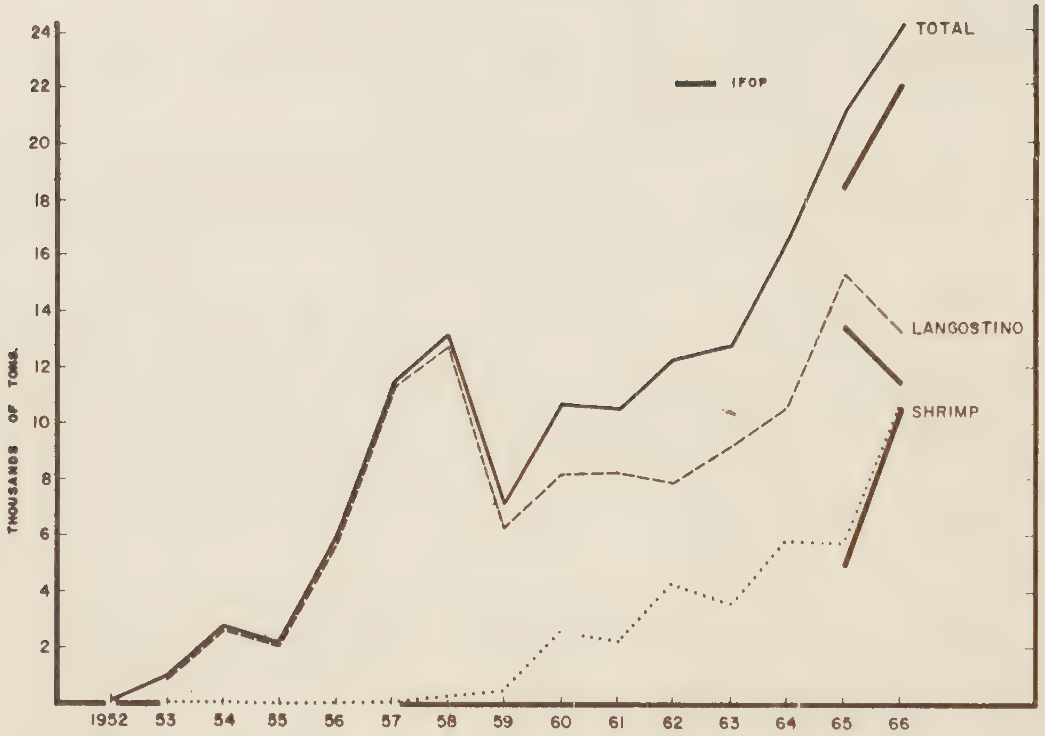

Fig. 2 Annual landings of shrimps and langostino; data supplied by the Department of Fish and Game (1952 to 1966) and IFOP (1965 to 1966).

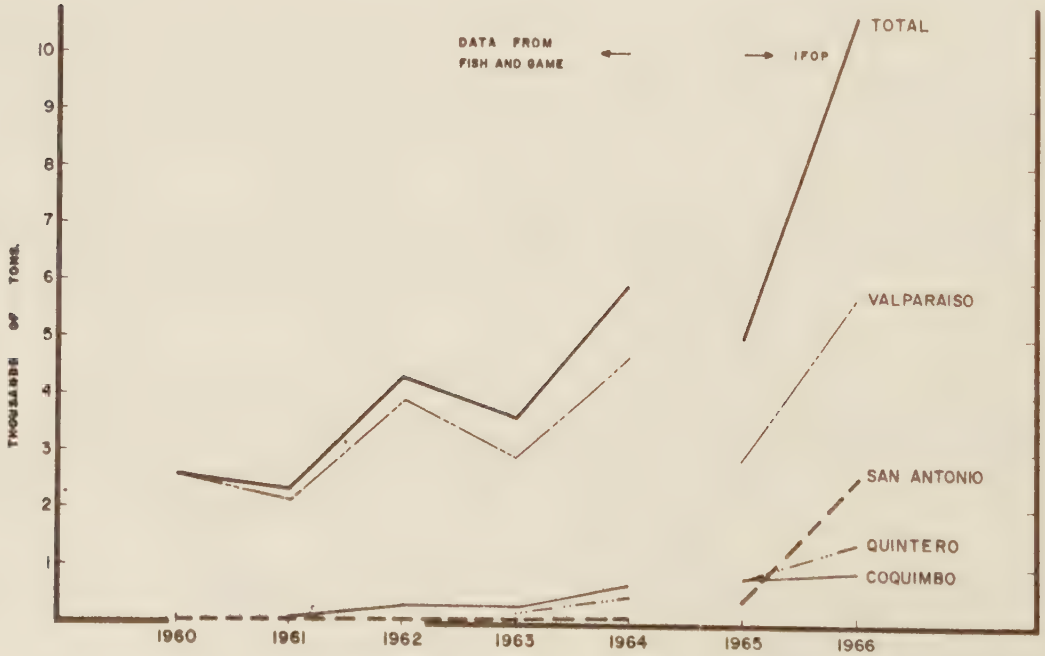

Fig. 3 Annual shrimp landings by ports, 1960 to 1966; data from the Department of Fish and Game (1960 to 1964) and IFOP (1965 to 1966).

TABLE I

The fishing fleet at Valparaiso 1960-1966, showing the number of calendar months during which boats fished for shrimps or langostino and details of their construction

Boat	Months spent fishing in year							Overall length (m)	Gross Registered Tonnage	Year of Construction
	1960	61	62	63	64	65	66			
V	-	10	9	9	6	-	-	19.1	46	1954
VI	-	8	10	10	11	10	8	17.2	51	1949
XI	3	11	12	12	9	10	12	21.8	84	1956
XII	-	-	-	-	11	9	11	37.2	280	1930
XIII	-	-	-	-	11	12	10	37.2	273	1930
XIV	9	11	12	3	9	11	11	20.7	66	1943
XV		-	-	-	10	11	12	21.9	74	1961
XVI				-	10	7	12	20.0	63	1963
XVII					5	11	10	20.3	76	1964
XVIII				-	11	12	11	20.1	61	1963
XIX	7	11	9	-	-	-	-	20.2	71	1958
XX	1	-	-	-	-	-	-	16.8	40	1920
XXI	1	-	-	-	-	-	-	19.2	64	1957
XXII	2	-	-	-	-	-	-	19.2	61	1957
XXIII	-	6	4	2	-	-	-	17.0	50	1958
XXIV	-	7	-	-	-	-	-	21.2	69	1947
XXV	-	12	8	-	-	-	-	17.0	70	1958
XXVI	-	-	2	9	5	2	-	20.0	54	1931
XXVII	-	-	-	-	1	-	-	15.0	27	1960
XXVIII				-	-	-	12	20.1	61	1963
XXIX					-	4	10	23.5	94	1964
XXX			-	-	-	2	-	19.8	87	1962
XXXI						3	7	21.9	106	1965
XXXII	-	-	-	-	-	1	2	21.4	55	1945
XXXIII					-	3	-	18.8	68	1964
XXXV						-	12	21.4	106	1965
XXXVI				-	-	-	11	25.1	149	1963
XXXVII				-	-	-	9	25.1	149	1963

TABLE II

Average numbers of trips per month from Valparaiso, obtained by comparing the same boats (A) in pairs of years from 1961 to 1966 (this procedure was necessary because the same boats were not represented throughout the period) and (B) boats which fished in 1964, 1965 and 1966

	Number of boats	1961	1962	1963	1964	1965	1966
A	8	16.0	15.9				
	8		15.1	12.3			
	9			13.0	12.7		
	10				12.3	11.1	
	12					11.4	10.5
B	9				13.2	11.3	10.6

In October and November 1965, Mistakidis and Henríquez (1966) made a more detailed trawl survey of the area between 35° and 39°S (Fig. 1). They concluded that commercial concentrations of shrimps and langostino occurred north of latitude 37° (near Talcahuano) but not farther south. A re-examination of the area at the end of March 1966 confirmed this pattern of distribution, but gave somewhat lower catches of shrimps. The November maximum and average catches were about 1,740 kg and 530 kg per h respectively, compared with around half these quantities in March. The authors suggested that the difference may have resulted from a horizontal migration at the approach of winter.

The area between 35° and 37°S, which had been shown to contain commercial densities, was resurveyed in November 1966 in conjunction with a foreign company, but this time using different gear supplied by the company. As in the previous November, maximum catches of shrimp exceeding 1,700 kg/h were taken, with an average of 750 kg/h (Fig. 13). The company made an immediate application for permission to establish plant at Talcahuano, where, to date, shrimp and langostino have not been processed.

A short survey off Taltal (Lat. 25°S) in April 1966 failed to locate more than a few specimens of shrimp and langostino.

4 CATCH AND EFFORT

The published statistics of the Department of Fish and Game give information only on monthly and annual landings by ports, but details of the boats and the number of trips each month have also been supplied by them privately. Fig. 2 and Table III show the annual landings of shrimps and langostino, both of which have been increasing fairly steadily. The weight of the shrimp catch has always been much smaller than that of langostino. Mistakidis and Henriquez (1966) suggested that this may have been due to lack of adequate equipment to trawl in deeper waters for shrimps. In Fig. 3 the annual landings of shrimps at Valparaíso are clearly seen to be much more important than at the other three ports, but San Antonio is now rapidly increasing in importance.

Monthly landings given in Fig. 4 are notable for the distinct reduction in catches of shrimps during the winter months, around July, and this would appear to be related in some way to the breeding period (see Section 6). However, according to the processors, there is no problem about the yield or preparation of berried shrimps, nor about their availability on the normal fishing grounds. They consider that the lowered catches result from bad winter weather, during which boats are forced to remain nearer to the ports, where however catches of langostino remain good. Maximum shrimp catches correspond in general to the lowest langostino catches, and occur particularly in summer (December to February) when the langostino are moulting (Fig. 4).

The standard technique of assessing availability of stocks in different years, by relating catches to some unit of effort, is here complicated by a number of factors. The vessels contributing to the annual effort may not be identical from year to year, and their wide range of size and fishing power has already been stressed (Table I). The problem of mixed catches needs careful consideration, since shrimps may be taken whilst trawling primarily for langostino, and vice-versa. To date, the only available statistic of effort has been the number of trips, but, with the exception of Coquimbo, there has been no information on the duration of each trip, the number of hours of trawling or the fishing position. Fig. 5 shows the available information on the total number of trips each year made by boats whose catches were entirely or mostly shrimps, and entirely or mostly langostino. Fig. 5B also shows how the largest part of the effort has been directed towards langostino, though the number of trips for shrimps rose from under 30 percent before 1962 to over 40 percent in 1966. The percentage of shrimps in the total catch followed the effort figures quite closely. In 1963 the effort for both species (Fig. 5A) and the catch of shrimps (Fig. 2) were greatly reduced when boats were concentrating on hake. In Fig. 6, which expresses the catch per trip for shrimps and for langostino for the same boats as in Fig. 5, it can be seen that although the effort for both species during 1963 was low (Fig. 5A) the catch per trip was unusually high. This is unlikely to have resulted from longer trips during 1963, because although the number of

TABLE III

Annual landings of shrimps and langostinos by ports 1952 - 1966.
Data from the Department of Fish and Game (1952 - 1964) and IFOP
(1965 - 1966, in metric tons)

YEARS	COQUIMBO		QUINTERO		VALPARAISO		SAN ANTONIO		TOTAL	
	shrimp	langostino	shrimp	langostino	shrimp	langostino	shrimp	langostino	shrimp	langostino
1952	-	-	-	-	20.0	-	2.0	-	22.0	-
1953	-	26.0	-	-	23.0	904.0	3.0	-	26.0	930.0
1954	-	-	-	-	55.0	2,644.0	31.0	-	86.0	2,644.0
1955	-	26.0	-	-	64.0	2,011.0	5.0	12.0	69.0	2,049.0
1956	-	782.0	-	-	113.0	4,824.0	2.0	100.0	115.0	5,706.0
1957	-	3,395.0	-	-	13.0	7,425.0	116.0	564.0	129.0	11,384.0
1958	-	4,491.0	-	-	108.0	7,863.0	274.0	473.0	382.0	12,827.0
1959	-	568.0	-	-	685.0	5,695.0	36.0	102.0	721.0	6,365.0
1960	-	1,474.2	-	-	2,615.1	6,520.0	17.8	127.3	2,632.9	8,121.5
1961	115.1	1,189.0	-	-	2,214.0	6,470.7	24.0	488.1	2,353.1	8,147.8
1962	332.1	1,373.9	-	-	3,981.0	5,707.7	33.0	904.7	4,346.1	7,986.3
1963	314.0	1,722.7	251.0	573.8	2,989.0	6,101.1	79.6	850.4	3,634.0	9,248.0
1964	727.7	1,759.5	463.1	2,090.3	4,683.0	5,782.3	73.1	1,023.5	5,947.0	10,655.6
1965	816.0	2,037.0	786.6	2,054.6	2,962.0	7,152.0	451.0	2,142.0	5,015.6	13,385.0
1966	901.0	1,698.0	1,417.0	976.0	5,710.0	5,842.0	2,943.0	4,153.0	10,911.0	11,269.0

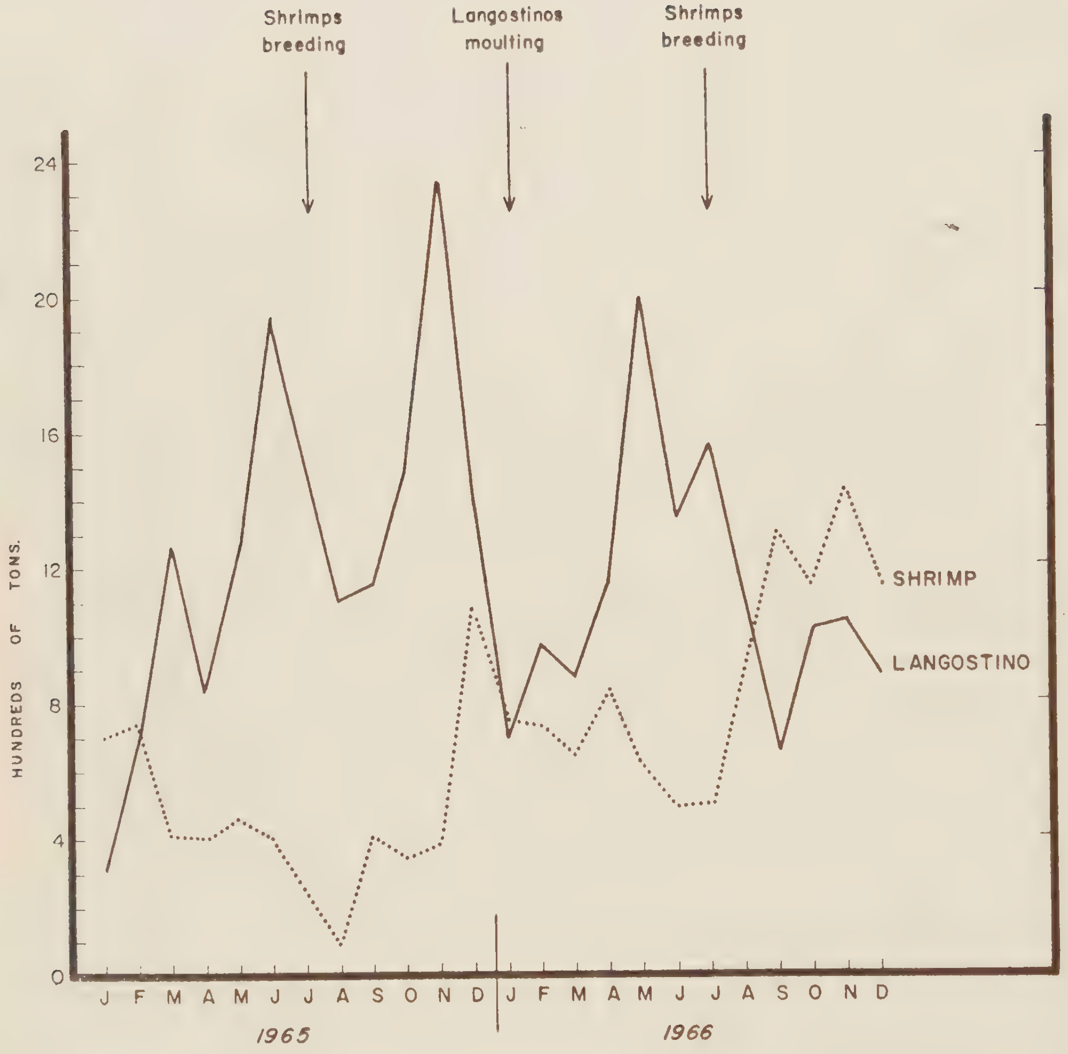

Fig. 4 Total landings by months of shrimps and langostino; data from the Department of Fish and Game.

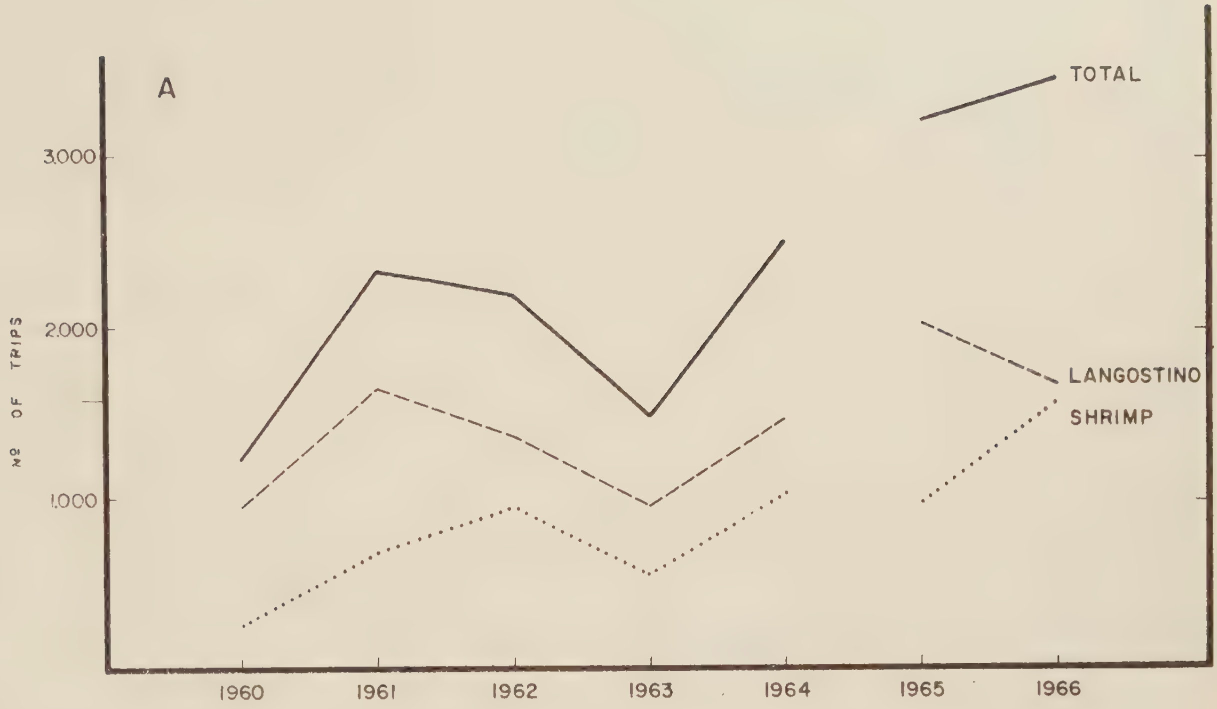

Fig. 5A Number of trips per year for shrimps and langostino, separately and in total, for boats whose catches were entirely or mostly shrimps and entirely or mostly langostino. (Source of data as in Fig. 3).

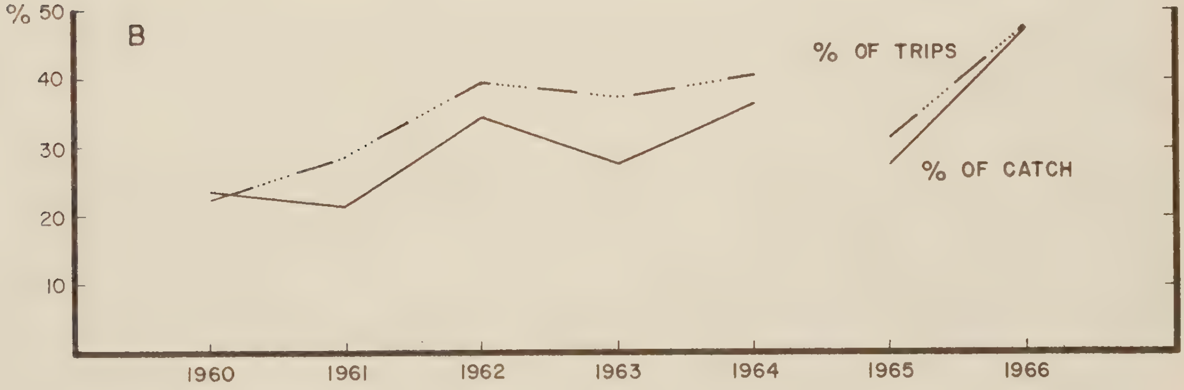

Fig. 5B The percentage of total trips which were made for shrimps, and the percentage of shrimps in the total catch. (Source of data as in Fig. 3).

trips per month was slightly less than in previous years (Table II), it was slightly more than in following years. There is no evidence on which to decide whether the higher catches were related to reduced total effort. The catch per trip for both species apparently continued to decline slightly between 1964 and 1965 although a change in the source of data (see below) may have affected their comparability. Between 1965 and 1966 the number of trips for shrimps and the catch both increased, but both were reduced for langostino (Figs. 2 and 5). The catch per trip for both groups, however, increased from 1965 to 1966 (Fig. 6). Despite a big increase in the number of trips in 1961 (Fig. 5), there was no increase in the year's catch of langostino, and a decrease in the year's catch of shrimp (Fig. 2). Fig. 6 shows that the catch per trip of both species was greatly reduced. It is possible that there is some connection between the lowered catches and the severe earthquake and tidal wave of May 1960.

In consideration of catch per unit of effort, the influence of improved vessels and gear, of improved techniques and experience of crews, and of improved collection of statistics must be considered. For example, in January 1965, IFOP established fulltime collectors of statistics at the three major ports; Quintero is covered also by the collector at Valparaíso. The collectors are also responsible for measurements and standard biological observations. In representing catch and effort statistics, any marked change in the method of collection has been noted, and, where possible, a comparison made with the result from the method used previously (Fig. 2). This assumes particular importance when comparing data for consecutive years, as in Figs. 2, 5 and 6, and should be considered when deciding whether the decrease in catch per trip between 1964 and 1965 (Fig. 6) is a real one. Up to January 1967, the length of trip was recorded regularly only at Coquimbo, but, since this will clearly be an important consideration in any further assessment, a concerted attempt will be made in future to obtain the exact length of each trip as well as the number of hours occupied in trawling.

The data from Coquimbo for 1965 and 1966 have been analyzed separately to give some idea of the difference in result between catch per trip and catch per day, using trips for which landings were composed solely of shrimps. Table IV demonstrates clearly the errors which would be inherent in comparing annual catch per unit of effort for the total fleet without an understanding of the variation in catch per unit of effort between months and between vessels. Differences between catch per trip and catch per day at sea are small for Coquimbo (Table IV and Fig. 7) because the majority of boats were at sea for no more than one day.

None of these data differentiate between whole and part days spent at sea, and the amount of time spent actually trawling is not known. Clearly such information is desirable for all ports.

Coombs (1966) has suggested a method for separating effort in a mixed fishery for crabs and lobsters, but some information was lost due to the pooling of data over weekly periods. Saetersdal, Henríquez and Sanhueza (MS) however attempted to obtain a basis for comparison of catch per unit of effort in the mixed shrimp-langostino fishery by selecting firstly boats with a history of fishing primarily for shrimps and langostino rather than for hake. From these the average number of trips per month was calculated for each year as an index of the length of voyage, and it was concluded that there was no consistent change in this figure between 1960 and 1965 for Coquimbo and Quintero. There was, however, a marked decrease in the number of trips per month from Valparaíso between 1962 and 1966 (Table II), and, since the main bulk of landings came from this port, this is consistent with the increasing catches per trip (Fig. 6). A separation was then made into (A) trips yielding catches composed only of shrimp or only of langostino and (B) those in which catches were mixed but predominantly either shrimp or langostino. Some errors may have been introduced here in separating majority catches merely on a weight basis, without considering the fact that for equal weights shrimps command a higher price than langostino. The proportion of the annual effort i.e. in number of trips, expended on catches classified under (B) was calculated using the ratio of shrimp catch to total catch of these boats. The results were expressed for individual vessels as average catch per trip per year. The results obtained from (A) were so little different from (A) plus (B) that the latter were used for the results shown in Table V. The same authors made an attempt to find a convertible index of fishing power but were defeated by the heterogeneity of the fleet with regard to type and equipment. The comparison between

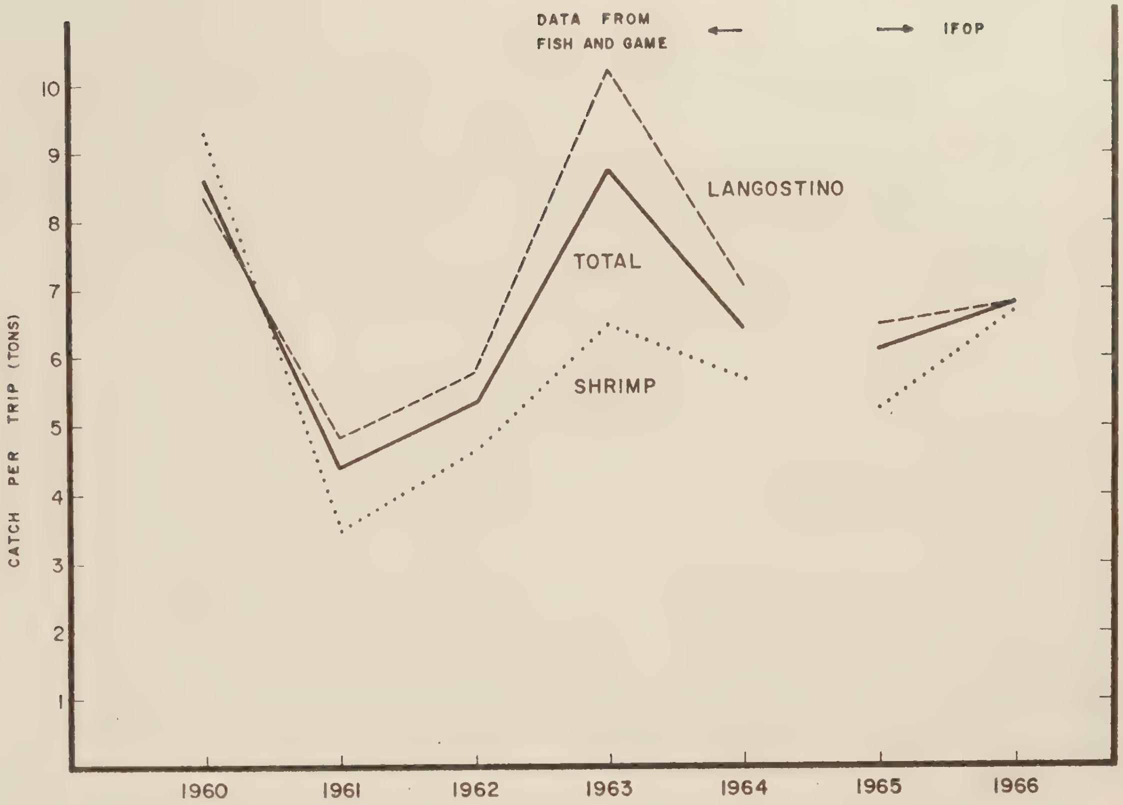

Fig. 6 Mean catch per trip for each year from 1960 to 1966 for the same boats as in Fig. 5, showing shrimp and langostino catches separately and combined. (Source of data as in Fig.3).

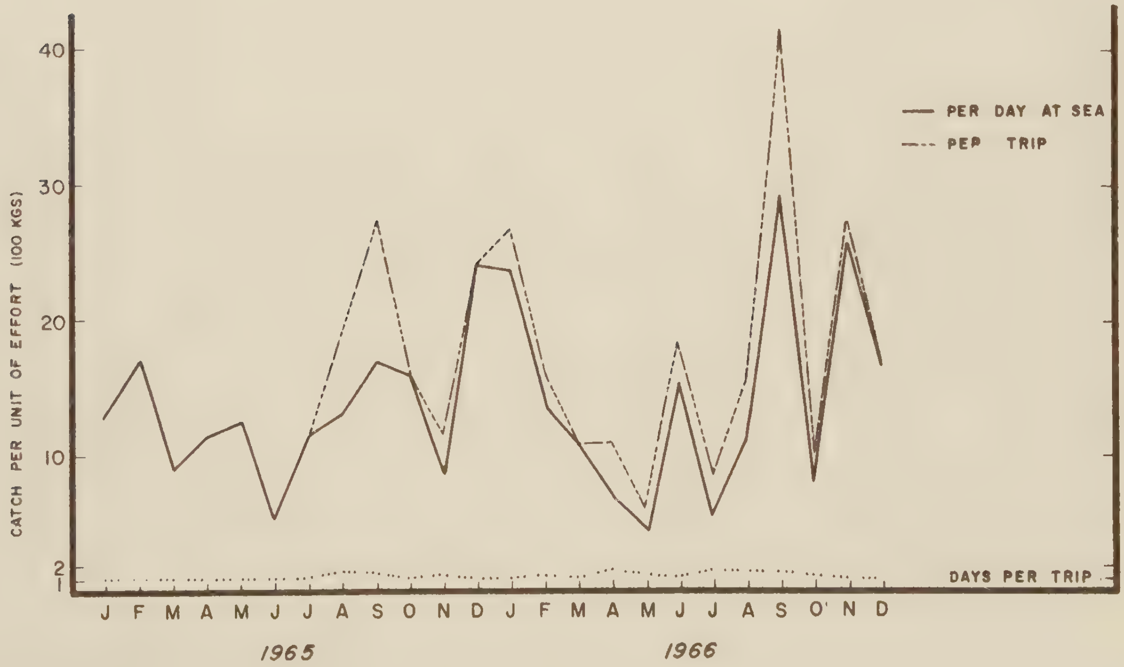

Fig. 7 Comparison of mean catch per day and mean catch per trip each month during 1965 and 1966 for Boat II at Coquimbo, together with mean number of days per trip.

TABLE IV

Mean catch per day, catch per trip and number of days per trip each month during 1965 and 1966 from Coquimbo (unit 100 kgs)

	Boat		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
1965	I	a	25.7	27.0	12.1	17.0	18.2	9.4	21.7	19.4	15.8	8.6	1.0	-	16.8
		b	25.7	27.0	12.1	17.0	18.2	9.4	21.7	24.6	17.9	14.3	2.0	-	18.1
		c	1	1	1	1	1	1	1	1.3	1.1	1.7	2	-	1.1
	II	a	13.2	17.2	9.3	11.5	12.1	5.4	11.6	12.8	16.9	16.0	8.7	24.2	14.0
		b	13.2	17.2	9.3	11.5	12.1	5.4	11.6	19.1	27.5	16.0	11.7	24.2	14.9
		c	1	1	1	1	1	1	1	1.5	1.6	1	1.3	1	1.1
	III	a	14.4	13.6	9.5	9.8	9.4	9.3	15.8	10.5	20.7	17.3	10.8	23.2	13.6
		b	14.4	13.6	9.5	9.8	9.4	9.3	15.8	14.4	25.3	17.3	10.8	23.2	14.0
		c	1	1	1	1	1	1	1	1.4	1.2	1	1	1	1.0
	IV	a	22.9	12.5	8.4	-	-	1.8	10.7	12.4	4.8	4.4	5.5	12.1	10.9
		b	22.9	12.5	8.4	-	-	1.8	10.7	12.4	6.3	6.8	11.0	12.1	11.8
		c	1	1	1	-	-	1	1	1	1.3	1.6	2	1	1.1
	V	a	-	-	-	-	7.4	3.0	-	-	-	-	8.7	-	7.4
		b	-	-	-	-	7.4	3.0	-	-	-	-	8.7	-	7.4
		c	-	-	-	-	1	1	-	-	-	-	1	-	1.0
	VI	a	-	-	-	-	5	-	-	-	-	7	3	-	5.3
		b	-	-	-	-	5	-	-	-	-	7	3	-	5.3
		c	-	-	-	-	1	-	-	-	-	1	1	-	1.0
	VII	a	-	-	-	-	3	-	-	-	-	-	-	-	3.0
		b	-	-	-	-	3	-	-	-	-	-	-	-	3.0
		c	-	-	-	-	1	-	-	-	-	-	-	-	1.0
	VIII	a	-	-	-	-	-	-	-	-	-	-	11	-	11.0
		b	-	-	-	-	-	-	-	-	-	-	11	-	11.0
		c	-	-	-	-	-	-	-	-	-	-	1	-	1.0
1966	I	a	24.4	21.0	12.7	-	-	-	-	-	-	-	-	25.1	20.9
		b	25.5	22.9	13.6	-	-	-	-	-	-	-	-	25.1	22.1
		c	1	1.1	1.1	-	-	-	-	-	-	-	-	1	1.1
	II	a	23.4	13.6	11.1	7.2	4.5	15.0	5.8	11.1	29.3	8.3	25.6	16.4	16.4
		b	26.7	15.9	11.1	10.8	6.0	18.3	8.8	15.6	41.0	10.0	27.1	16.4	19.1
		c	1.1	1.2	1	1.5	1.3	1.2	1.5	1.4	1.4	1.2	1.1	1	1.2
	III	a	19.6	-	5.3	6.6	9.5	9.3	9.1	1.0	5.1	6.4	5.1	10.0	9.7
		b	24.0	-	5.3	8.3	9.5	12.3	10.5	1.0	6.0	6.4	5.1	10.0	10.8
		c	1.2	-	1	1.3	1	1.3	1.2	1	1.2	1	1	1	1.1
	IV	a	12.9	11.6	15.9	6.3	12.6	9.2	7.0	7.4	-	-	18.0	16.5	12.2
		b	15.8	12.6	15.9	8.6	12.6	10.2	7.0	7.4	-	-	18.0	16.5	13.2
		c	1.2	1.1	1	1.4	1	1.1	1	1	-	-	1	1	1.1
	V	a	-	-	4.0	-	-	-	-	-	-	-	-	-	4.0
		b	-	-	4.0	-	-	-	-	-	-	-	-	-	4.0
		c	-	-	1	-	-	-	-	-	-	-	-	-	1.0
	VI	a	-	-	5.0	-	-	-	-	-	-	-	-	-	5.0
		b	-	-	5.0	-	-	-	-	-	-	-	-	-	5.0
		c	-	-	1	-	-	-	-	-	-	-	-	-	1.0
	VIII	a	-	-	-	-	-	17.4	25.1	18.2	32.9	14.0	22.4	-	22.1
		b	-	-	-	-	-	21.1	25.1	24.6	35.1	16.0	22.4	-	24.8
		c	-	-	-	-	-	1.2	1	1.4	1.1	1.1	1	-	1.1

a : Catch per day b : Catch per trip c : Mean days per trip years had therefore to be based on single identified vessels (Table V A and Fig. 8).

The results for Coquimbo and Quintero show little change between 1960 and 1966, but from Valparaíso the level of catches was much more variable between boats, reflecting the heterogeneity of the fleet. One boat (number XI) showed a dramatic increase from 1960 to 1966, while another (XIII) showed the same increase in only two years. It is known that the captain of boat XI is the most skilful in the fleet, and this increase could reflect his increasing efficiency, or alternatively, there was a marked decrease in the number of trips per month from 1964 to 1966 of both vessels (Table II), so that the results may merely represent longer trips with larger catches per trip. This emphasizes the need for more information on the composition of trips.

Similarly, examination of monthly catch per trip on a fleet basis is not very meaningful without taking into consideration the different boats fishing each month. A comparison of monthly catch per trip between years is made difficult by the fact that there is no fishing for shrimps in some months, and there is no constancy about the particular months fished by any boat. Even for one boat there was no consistent pattern of monthly catch per trip from year to year.

In order to obtain an average value of annual catch per trip unweighted by the actual landings, Saetersdal, Henríquez and Sanhueza (MS) expressed the catches per trip of individual vessels in 1965 and 1966 as percentages of the catch per trip in 1964 (Table V B). There was no consistency in the pattern of increase or decrease in catch per trip between 1964 and 1966, and, excluding boat XIII, the mean result varied little between the 3 years. As is usually the case, the use of percentages showed a great tendency to bias, and the results obtained from averaging the original catch per trip figures seem to be more representative (Table V A).

5 SIZE AND SEX COMPOSITION

In March 1965, IFOP commenced sampling commercial landings of shrimps and langostino for size and sex composition. By July 1965, regular monthly samples were being measured by permanent collectors at Valparaíso and Coquimbo, and this was extended to San Antonio in January 1966. Measurements of carapace length from the eye socket to the posterior mid-dorsal edge of the carapace are made using dividers and a steel rule, and recorded to the nearest half millimetre below.

The proportion of male shrimps in the samples was usually less than 50 percent (Fig. 9 A), averaging 32 percent for 1965 samples taken mostly at Coquimbo, and 29 percent for 1966 samples from all three ports. These figures included a maximum of 64 percent (Coquimbo in November 1965) and a minimum of 3 percent (Valparaíso in July 1965 and Coquimbo in March 1966). This compares with the average of 25 percent (50 percent in October and 0 percent in June and July) obtained by Bahamonde and López (1960) from Santiago market samples examined during 1958 and 1959 (Fig. 9 B). Both the latter samples, and those from Coquimbo in 1966 contained very small numbers of males in March, June and July, but this did not apply to Valparaíso, or to the average. At the present state of knowledge, no speculation will be made as to the cause, remembering that samples have been grouped here according to port of landing, and not according to fishing area, which should be done at a later stage.

The size compositions of males, total females and ovigerous females are given in Fig. 11. The modal and average sizes for all three are greater for shrimps landed at Valparaíso than Coquimbo (San Antonio is most like Valparaíso) and this must be remembered when comparing the average size in different years as a way of indicating intensity of fishing. Saetersdal, Henríquez and Sanhueza (MS) used this method to compare the recent size composition with that given by Bahamonde and López (1960), but they were careful to select samples taken from a comparable annual period (June 1965 to June 1966) and from a similar area (Valparaíso and San Antonio) to that represented in the 1958-59 samples. They concluded that the size compositions for the two periods were so similar that there was no evidence that the fishery had significantly increased the total mortality of the stock.

TABLE V

(A), Mean annual catch per trip (tons) for catches consisting entirely or principally of shrimps. (B), values for 1965 and 1966 as percentage of 1964 values. Boats from Valparaiso. (After Saetersdal, Henriquez and Sanhueza, MS)

Boat	(A) 1960	1961	1962	1963	1964	1965	1966	(B) As % of 1964 value 1965	1966
V	-	0.8	1.0	3.0	2.5	-	-	-	-
VI	-	1.3	1.9	6.2	9.4	4.5	4.5	47.9	47.9
XI	2.9	4.5	8.2	9.7	16.4	16.2	17.3	98.8	105.5
XII	-	-	-	-	1.9	2.2	5.6	115.8	294.7
XIII	-	-	-	-	1.3	4.3	16.7	330.8	1284.6
XIV	4.0	2.8	3.4	3.2	3.7	3.9	2.9	105.4	78.4
XV	-	-	-	-	12.3	14.7	12.5	119.5	101.6
XVI	-	-	-	-	12.1	7.8	9.1	64.5	75.2
XVII	-	-	-	-	3.0	3.2	3.7	106.7	123.3
XVIII	-	-	-	-	11.1	7.5	12.4	67.6	111.7
XIX	1.6	1.1	2.0	-	-	-	-	-	-
Mean for 9 boats (excluding V)					7.9	7.1	9.4	117.4	247.0
Mean for 8 boats (excluding V and XIII)					8.7	7.5	8.5	90.8	117.3

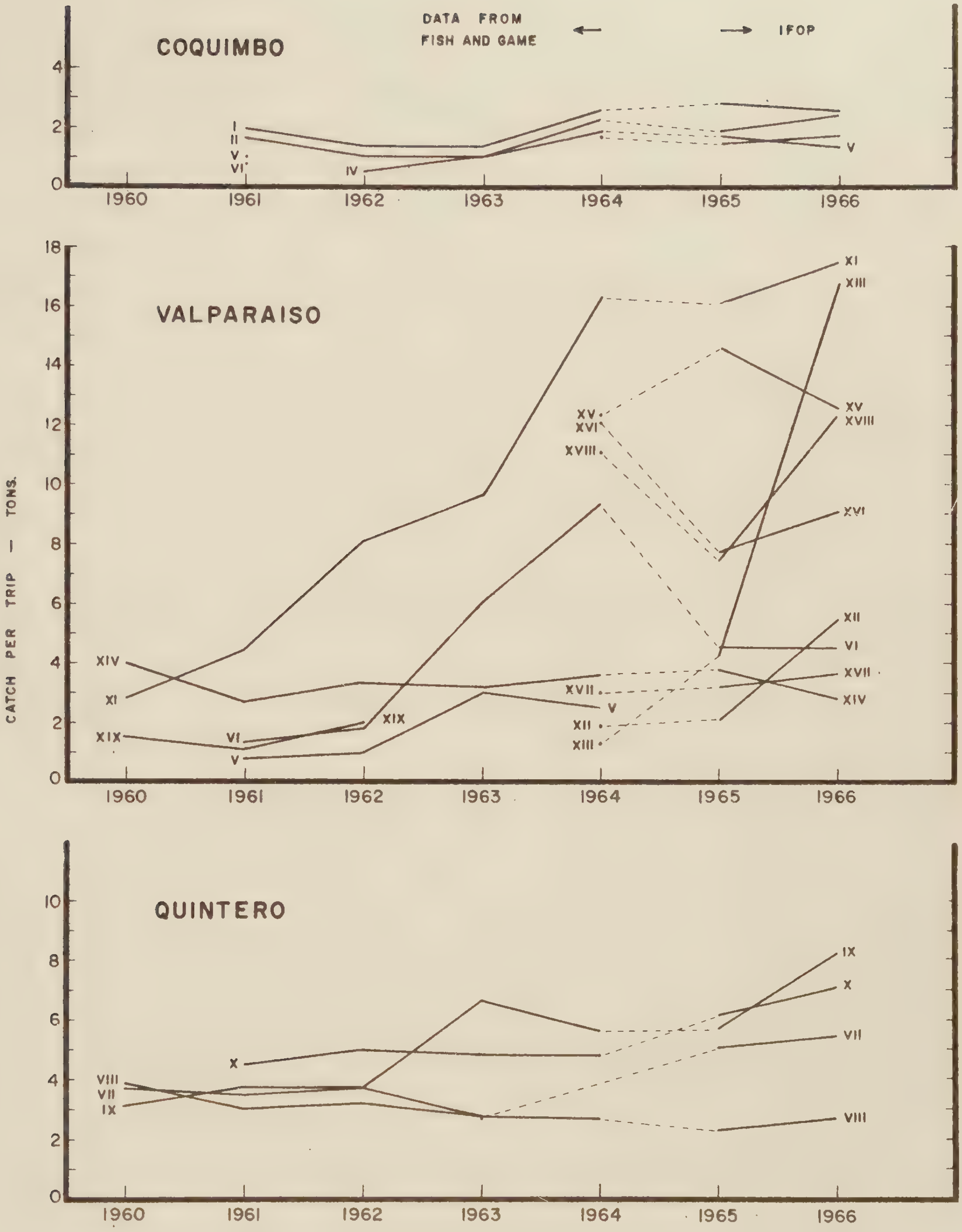

Fig. 8 Mean annual catch per trip of shrimps for identified vessels from Coquimbo, Valparaíso and Quintero (after Saetersdal, Henríquez and Sanhueza, MS). (Source of data as in Fig. 3)

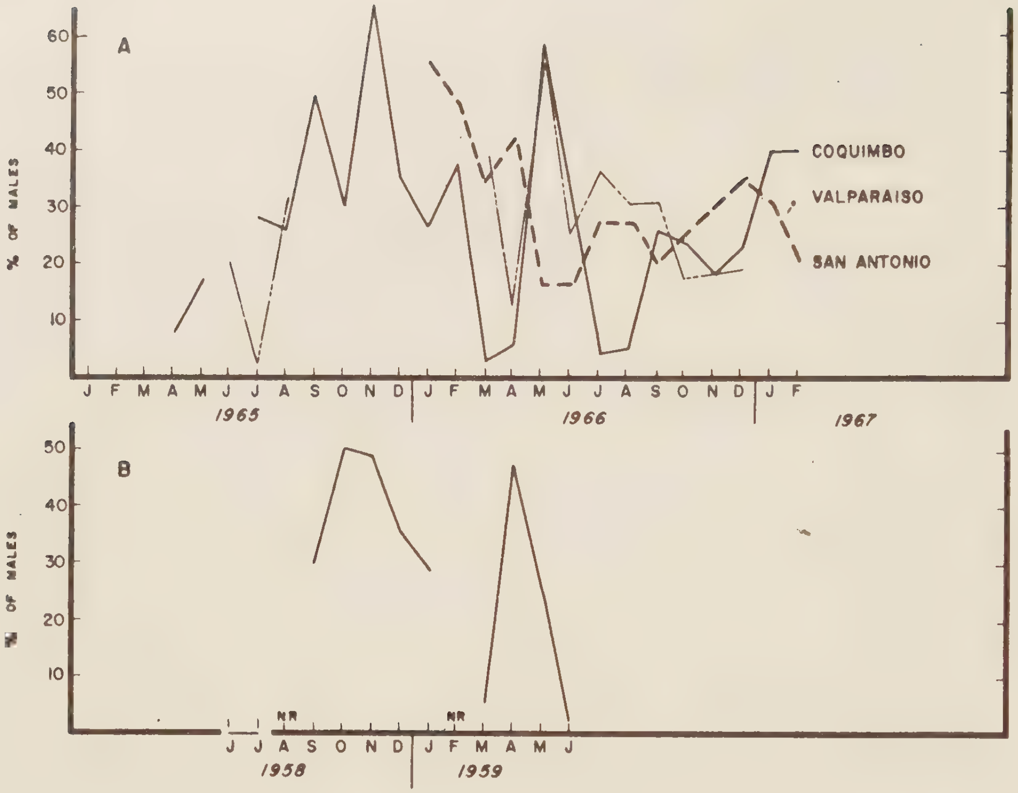

Fig. 9 Percentage of males in monthly samples (A) from 3 ports in 1965 to 1967, and (B) in 1958 to 1959 (data from Bahamonde and López, 1960).

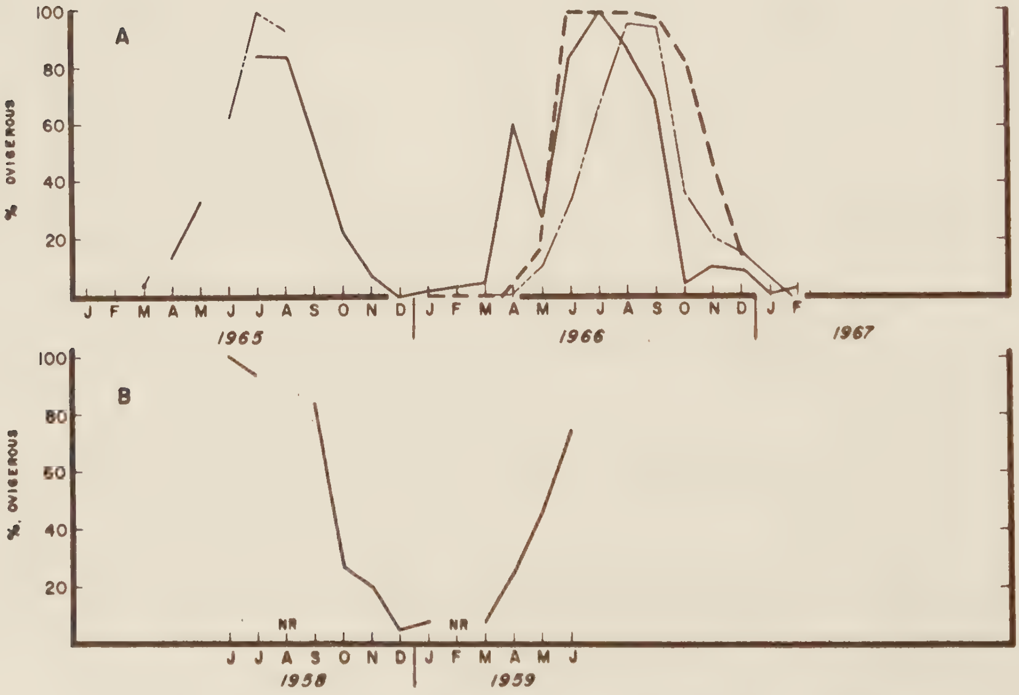

Fig. 10 Percentage of females which were ovigerous in monthly samples. (A) and (B) as in Fig. 9.

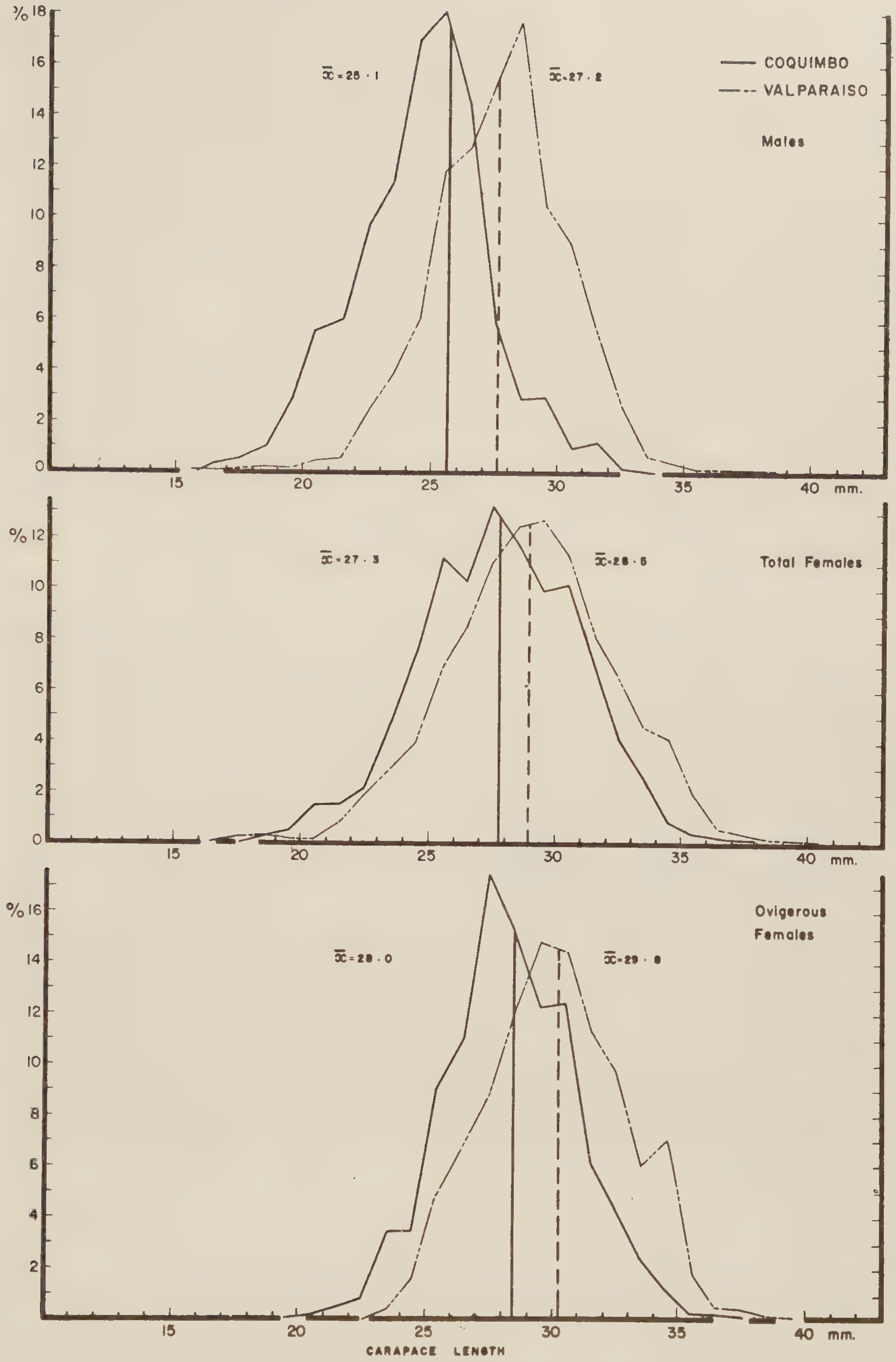

Fig. 11 Mean carapace length composition of males, total females and ovigerous females in samples taken during 1966 at Coquimbo and Valparaiso, shown as percentages in each millimetre group. Mean carapace lengths are also shown.

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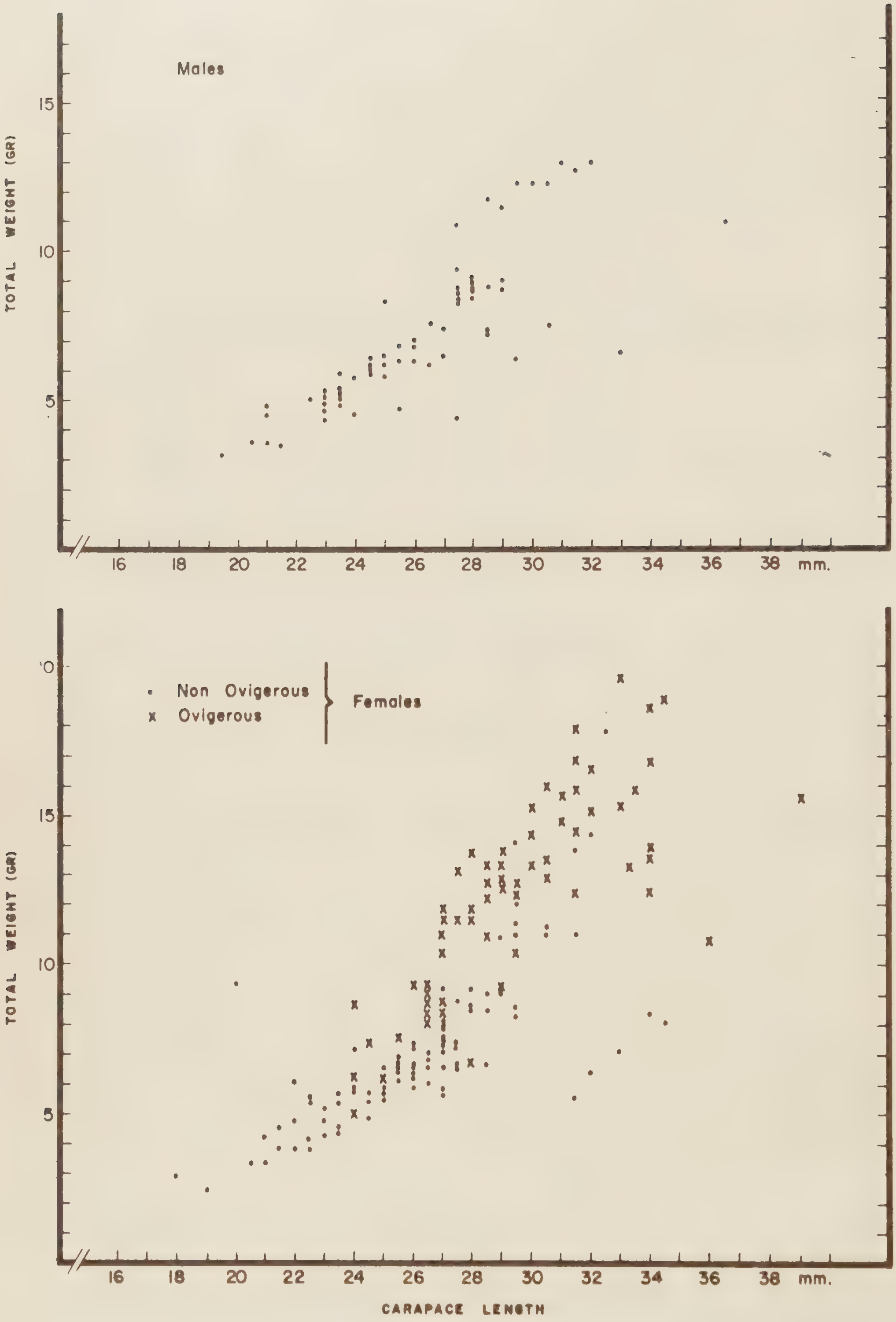

Fig. 12 Relationship between total weight and carapace length for males, non-ovigerous and ovigerous females from Valparaíso, 15 June 1966.

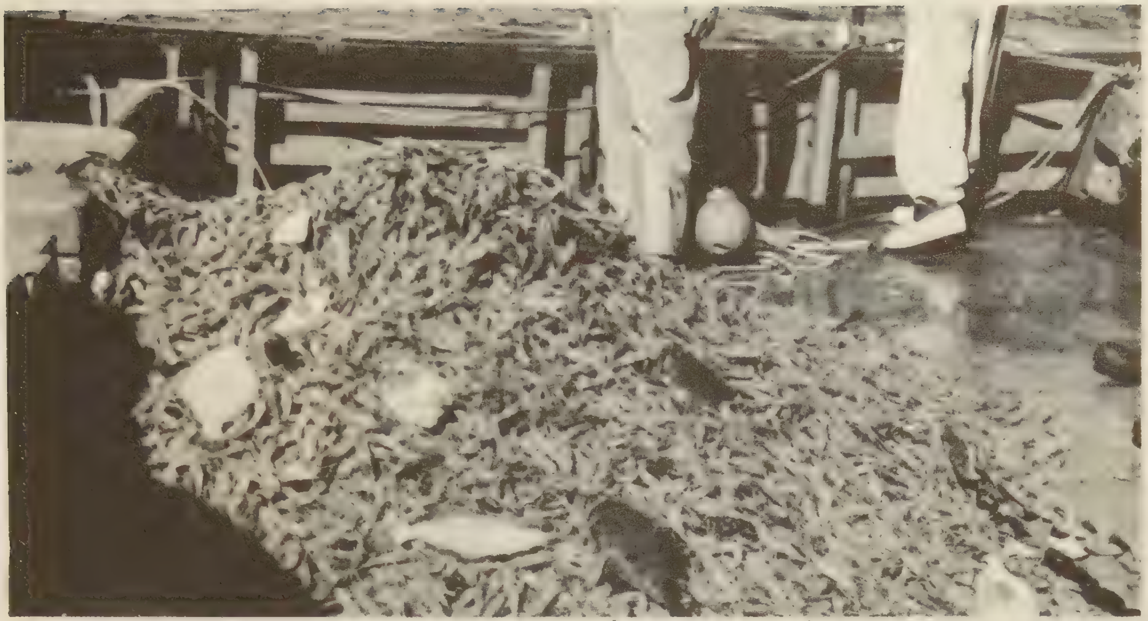

Fig. 13 Part of a 30-min haul (about 800 kg) of Heterocarpus reedi (with Paralichthys sp.) taken on M/S TIBERIADES off Talcahuano in November 1966. (Photo: G. Henríquez).

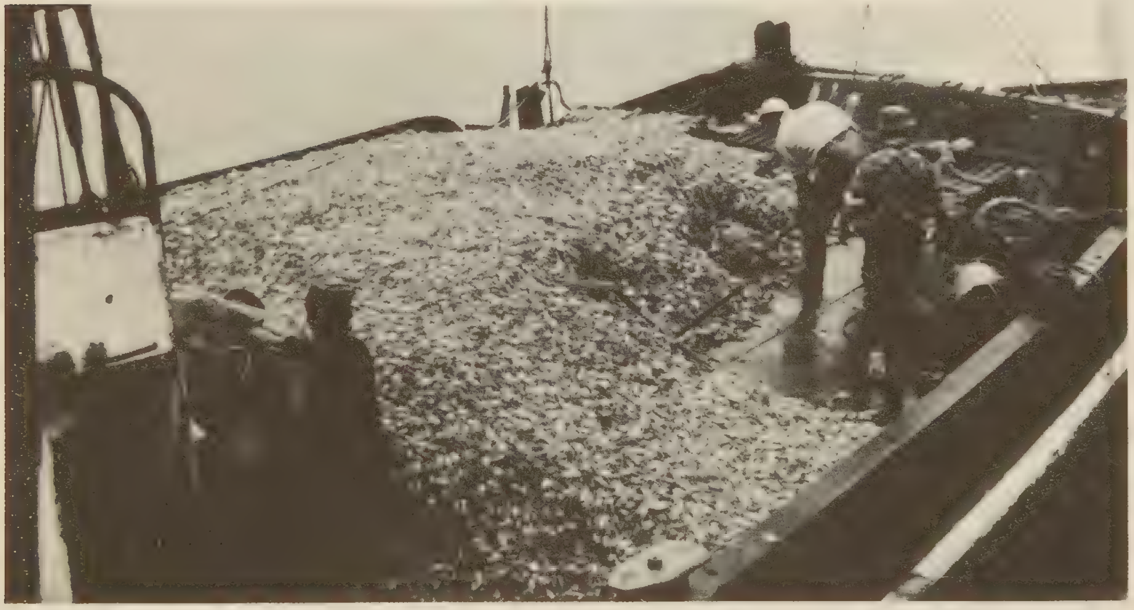

Fig. 14 A day's catch of Cervimunida johni by a commercial vessel off Coquimbo. (Photo: M. N. Mistakidis).

6 BREEDING

Records were kept of the numbers of ovigerous females in the samples. Fig. 10A is composed from the available information from samples from various sources in 1965 and 1966. Although there is some slight difference in the positions of the modes from samples from the different ports, which would warrant a more detailed examination of the precise location of samples, the general pattern is clear; ovigerous females showed a maximum (up to 100 percent) during the winter months and a minimum (down to 0 percent)in the summer. The results of Bahamonde and López (1960) were very similar (Fig. 10 B). Samples taken in exploratory cruises off Talcahuano gave average percentages of ovigerous females more like Valparaíso than Coquimbo i.e. 60 percent in November 1965, 2 percent in March 1966 and 45 percent in November 1966, supporting the suggestion of later occurrence of ovigerous females on more southerly grounds. It should be mentioned however that the results from individual samples in November 1965 were extremely variable, ranging from 12 to 100 percent. The fact that more than 50 percent of female shrimps are ovigerous during half the year was used by Saetersdal, Henríquez and Sanhueza (MS) to point out the impracticability of the regulation prohibiting the taking of shrimp and langostino with visible eggs. Such specimens would be unlikely to survive if returned to the sea. During the peak period of ovigerous females, all females in the July sample from Coquimbo, from a carapace length of 20 mm, carried eggs. At Valparaíso the smallest ovigerous female was 23 mm, and at San Antonio 19 mm.

Bahamonde (1958) made estimates of the number of eggs per female shrimp over a range of carapace lengths. The numbers ranged from 1,700 per 25 mm female, to 3,320 at 35 mm.

7 LENGTH/WEIGHT RELATIONSHIP

Brief mention must be made here of the relationship between length and weight which is an essential part of any population study. Preliminary results (Fig. 12) suggest that there is no difference between males and non-ovigerous females, but that egg-bearing females are heavier for the same carapace lengths. Summer and winter samples from Valparaíso gave similar results, and there was no difference between summer samples from Valparaíso and San Antonio. Regression lines (Hancock and Edwards, 1966) have not yet been fitted.

8 SUMMARY AND CONCLUSIONS

The information presented and reviewed represents observations to date relevant to a stock assessment of the Chilean shrimp fishery, and needed for the framing of regulations. It includes data on the distribution of the fished and unfished stocks, on catch and effort, on size and sex composition and incidence of berried females, and on the relationship between carapace length and body weight. The data are by no means complete, but this analysis has served to show their shortcomings, and already measures have been taken for their improvement. Unfortunately there is no information on growth rates.

More detailed records of effort are required, but it seems clear that there has been no consistent change in the average catch per trip. The gradual decrease in the number of trips per month from Valparaíso is, however, indicative of longer trips, and in 1966 there was a substantial increase in the average catch per trip from this port. This coupled with a greater total effort gave rise to a marked increase in total landings during 1966. It seems reasonable, therefore, to agree with the conclusion of Saetersdal, Henríquez and Sanhueza (MS) that not only does the fishery not seem to have had a great effect on the stock, but that in view of the discovery of stocks as yet lightly fished, there could be a further increase in the Chilean catch of shrimps.

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SOME ASPECTS OF THE BIOLOGY OF *Solenocera indica* Nataraj

by

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Abstract

The biology of *Solenocera indica* Nataraj, commercially exploited around Bombay, was studied based on samples from fishermen's catches. The species is the same as *S. subnuda* Kubo and its geographic distribution extends from India to Borneo and Hong Kong. It feeds mostly on crustaceans and fish. Breeding behaviour was studied from the periodical occurrence of various maturity stages. The breeding period is protracted, with two peaks in December and April. Main spawning grounds are outside, and probably contiguous with, the fishing area. Males do not leave the fishing grounds for purposes of breeding. The entire population migrates offshore when salinity decreases. Average growth rates of adult females and males, as estimated from length frequency studies, are 6.96 mm and 6.49 mm per month respectively. Juveniles grow faster. Estimated life spans of female and male are 14 to 15 months and 9 to 10 months, respectively. Females always dominate the population.

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QUELQUES ASPECTS DE LA BIOLOGIE DE Solenocera indica Nataraj

Résumé

L'étude de la biologie de Solenocera indica Nataraj, espèce exploitée commercialement aux environs de Bombay, a été effectuée sur des échantillons provenant des prises des pêcheurs. L'espèce, identique à S. subnuda Kubo, est distribuée géographiquement de l'Inde à Bornéo et Hongkong. Sa nourriture consiste essentiellement en crustacés et en poissons. Le comportement en matière de reproduction a été étudié d'après l'apparition périodique des divers stades de maturité. La période de reproduction est très longue, avec deux pointes en décembre et en avril. Les principales frayères sont situées hors de la zone de pêche, et y sont probablement contigües. Durant la reproduction, les mâles ne quittent pas les fonds de pêche. Lorsque le taux de salinité décroît, toute la population effectue une migration vers le large. Le taux moyen de croissance des femelles et des mâles adultes, estimé sur la base d'études des fréquences de longueurs, est de 6,96 et 6,49 mm par mois, respectivement. Les formes juvéniles croissent plus rapidement. La durée de vie estimée des femelles et des mâles est respectivement de 14 - 15 mois et de 9 - 10 mois. Le nombre des femelles est toujours plus grand que celui des mâles.

ALGUNOS ASPECTOS DE LA BIOLOGIA DE Solenocera indica Nataraj

Extracto

Se ha estudiado la biología de Solenocera indica Nataraj explotado comercialmente en torno a Bombay, sobre la base de muestras tomadas de las capturas de los pescadores. Esta especie es igual a S. subnuda Kubo y su distribución geográfica se extiende desde la India a Borneo y Hong Kong. Se alimenta principalmente de crustáceos y peces. Se ha estudiado su desarrollo por la aparición periódica de las diversas fases de su madurez. El período de cría es largo alcanzando dos máximos en diciembre y abril. Los lugares principales de desove se hallan fuera de la zona pesquera y probablemente contiguos a ella. Los machos no abandonan las áreas pesqueras a fines reproductores. Toda la población emigra hacia alta mar cuando disminuye la salinidad. El promedio de crecimiento de las hembras y machos adultos, calculado mediante estudios de frecuencia de tallas es de 6,96 mm y 6,49 mm mensuales, respectivamente. Las formas juveniles crecen más deprisa. El ciclo vital de hembras y machos se calcula en un período de 14 a 15 meses y de 9 a 10 meses, respectivamente. El número de hembras, en la población, es siempre dominante respecto al de machos.

1 INTRODUCTION

Our knowledge of the biology of penaeid prawns is mainly based on the various accounts available on the species of the sub-family Penaeinae; and very little information is available on Solenocerinae. Except for the recent accounts on the natural history of *Solenocera subnuda* (Cheung, 1963; Hall, 1962), there has been only scattered information on the larval and developmental history of other species of Solenocerinae. Commercial exploitation of this group is only to a very limited extent, the vast majority of these prawns being abyssal forms inhabiting waters beyond the continental shelf (Alcock and Anderson, 1894; Alcock, 1901; Burkenroad, 1934, Kubo, 1949; Bullis 1956). However, *Hymenopenaeus robustus* and *H. muelleri* in the Atlantic coast of America (Bullis, 1956; Eldred and Hutton, 1960), *S. membranacea* in the Mediterranean coast of Israel (Holthuis and Gottlieb, 1958), *S. subnuda*, *S. alticarinata*, *S. depress* and *S. bedokensis* from the sea around Hong Kong (Cheung, 1963) and *S. distincta* in the Seto inland sea of Japan (Yasuda, 1956) have been reported to occur in the prawn catche of these countries. Of these *S. subnuda* and *S. distincta* are of some minor fishery value. *S. indica* supports a considerable fishery around Bombay and it has been estimated to contribute 9.61 percent of the average annual prawn landings of 53,682 tons in Maharashtra (Kunju, 1967)

2 MATERIAL AND METHODS

Random samples from the commercial catches were collected from Sassoon Dock, Versova and Arnala. The distance from Versova to Arnala is about 32 km to the north and that from Versova to Sassoon Dock is about 28 km to the south. Versova and Sassoon Dock lie within the city of greater Bombay. Care was taken to ensure maximum randomness in the samples, by taking them before the catch had been sorted out and by combining the total sample from different fishing units. The gear used in catching these prawns is a fixed bag net, locally known as 'Dol', which is widely used all along the coast of Maharashtra. A smaller version of the net, locally known as 'Bokshi' is operated very close to the shore at Arnala. 'Dol' is used in all the three centres. The fishing grounds lie within the 30 to 40 m depth range at Versova and Arnala, whereas they are within 20 m depth at Sassoon Dock. The 'Bokshi' of Arnala is operated in waters of 6 to 7 m depth. Setna (1949) has given a fairly detailed account of the operation and construction of the 'Dol' of the Bombay coast.

Material from Arnala was obtained once a fortnight from November 1959 to June 1962, and from Versova and Sassoon Dock once a week from October 1959 to April 1965. Samples of different weeks of the month were combined to represent the month's sample. In all, about 8,000 prawns were examined. Total length was measured from the tip of rostrum to the tip of telson after having stretched the prawn dorsoventrally on a graduated scale. Carapace length was measured from the mid-dorsal line, opposite the posterior orbital margin, to the posterior end of the mid-dorsal line of the carapace, by using a vernier caliper calibrated to 1/10 mm. Measurements were recorded mostly from specimens preserved in 5 percent formaldehyde for about a month; only a few samples could be measured in the fresh condition.

Other details of techniques employed have been given in the appropriate sections.

3 SYSTEMATIC POSITION AND DISTRIBUTION

After the species was first described by Nataraj in 1945 several authors have dealt with the systematics of Solenocerinae, but none of them has referred to *S. indica*. This omission is particularly evident in the monograph of Kubo (1949) wherein six new species of *Solenocera* have been proposed, of which five are closely related to the Indian form. Among them *S. subnuda*, a species erected on material obtained from the south coast of Borneo appears to be the same as *S. indica*. The characters of the two species as described by the original authors were compared by the present author and slight variations were noticed in the post-rostral carina, antennular flagellum, second and third abdominal somites, thelycum and the pereiopods. On examination of a large

TABLE I

Percentage composition of the stomach contents of Solenocera indica

Sex	Size in mm	No. of prawns examined	Crustacea			Fish	Poly-chaetes	Molluscs	Sand	Debris	Miscella-neous
			Decapod	Copepod	Uniden-tified Crustacea						
Female	20-50	6	-	-	40.00	16.67	-	-	6.67	36.67	-
	51-70	24	47.50	1.67	7.50	8.75	6.25	2.09	0.83	24.59	0.83
	71-90	84	27.98	0.36	10.60	24.88	4.05	3.57	1.43	27.02	0.12
	91-110	32	54.69	2.19	-	27.19	-	-	-	15.94	-
	All sizes	146	35.89	0.96	8.97	22.40	3.36	2.40	1.23	24.59	0.21
Male	20-46	4	12.50	7.50	-	10.00	-	-	30.00	35.00	5.00
	47-70	76	27.63	1.05	15.13	22.24	2.36	1.05	1.84	27.76	0.92
	All sizes	80	26.88	1.38	14.38	21.63	2.25	1.00	3.25	28.13	1.13
Both sex		226	32.70	1.11	10.88	22.12	2.96	1.90	1.95	25.84	0.53

number of specimens of *S. indica* these variations were found to occur within the species and hence were not considered of specific significance.

Hall (1956) erected the species *S. kuboi* on material collected from Malaysian waters and compared it with *S. subnuda*. The differences noticed by Hall were mostly the same as mentioned above and these were subsequently reconciled (Hall, 1962) and *S. kuboi* and *S. subnuda* considered synonymous. His description and illustration of the antero-ventral region of the carapace of *S. subnuda* show perfect agreement with *S. indica*. However, the transitory spines along the lateral margins of the telson of juveniles are not found in *S. indica*.

Cheung (1960) pointed out the similarity between *S. indica* and *S. subnuda*, and his opinion that "in the absence of type specimens the name *subnuda* is to be preferred to *indica* for geographical reasons" is not considered acceptable for obvious reasons. Dr. A.J. Bruce of the Fisheries Research Station, Hong Kong, believes (personal communication) that the two forms are the same, but both are likely to be synonymous with *S. chinensis* Yu. Kubo and Hall seemed to be unaware of the work of Nataraj.

S. indica is found all along the coast of India. Nataraj (1945) recorded the species from Gulf of Cambay, Bombay, Madras, Visathapatnam, Orissa and Ganjam coasts, and from the sandheads and the mouth of River Hooghly. His material also came from Mergui Archipelago and Singapore. Ahmad (1957) recorded the species from Khulna in East Pakistan. As *S. subnuda* is to be considered a synonym of *S. indica* the range of distribution of the latter may be said to extend up to the coasts of Borneo and Hong Kong. All these records were from within 40 m depth.

Along the coast of Maharashtra the species is abundant, particularly around Bombay. In the course of the present study it was collected from Dahanu, Satpati, Arnala, Versova, Worli, Sassoon Dock, Alibag, Murud and Paj. Its abundance is conspicuous in Versova from where the largest catches are recorded.

4 FOOD AND FEEDING HABITS

The stomach contents of 146 females, ranging from 20 to 110 mm in length, and 80 males ranging from 20 to 70 mm in length, selected from samples of different months from all the three centres were examined in detail in order to determine the nature of feeding. The stomachs were dissected and the contents examined under microscope. The percentage composition of the constituents was determined by eye estimation, and analyzed separately for the various length groups of prawns. The stomach contents were found mostly in an advanced stage of digestion and hence identification of the constituents was extremely difficult.

The percentage composition of the stomach contents is given in Table I. The food items were classified as crustaceans, fish, polychaetes, molluscs, sand, debris and miscellaneous.

4.1 Crustaceans

It could be seen from the table that the most important item in the diet was of crustacean origin, constituting 44.69 percent of the stomach contents. The 51 to 70 mm and 91 to 110 mm groups among females and the 47 to 70 mm group among males were found to consume more of this item than the other size groups. Decapods such as *Acetes indicus* and *Palaemon tenuipes*, both of which were abundant in the inshore waters of Bombay, formed the dominant group among crustaceans. In several cases palaemonid zoeae were found in large numbers. Since *Palaemon tenuipes* is the only palaemonid found occuring in vast numbers in the area of investigation these zoeae were assigned to it. Most of them were found entire without having been mutilated by the masticatory or digestive processes. Calanoid copepods and fragments of various parts of other crustaceans constituted the rest of the crustacean item. These fragments were broken appendages, pieces of exoskeleton, setae, etc.

4.2 Fish remains

As stated earlier, it was extremely difficult to differentiate the identity due to the fish being found only in fragments consisting of various bones, eye balls, scales, otoliths and sometimes portions of the muscle, of very small fishes, probably larval or post-larval forms. This item constituted 22.12 percent of the stomach contents. Larger prawns were found to feed on fish more than the others.

4.3 Polychaetes

Setae and fragments of polychaetes constituted 2.96 percent of the stomach contents. Medium sized prawns of both sex were found to feed on this item more than the others.

4.4 Moluscs

Forming 1.90 percent of the stomach contents, these could be recognized only by the presence of broken pieces of shell, probably those of small gastropods.

4.5 Sand

Sand grains constituted 1.95 percent of the stomach contents and they were present in all the size groups, though more in the smaller prawns. Sand particles have, obviously, got in along with food ingested from the bottom of the sea.

4.6 Debris

In almost all the prawns examined a sizeable portion of the stomach contents (25.84 percent) consisted of unidentifiable finely ground up matter. The word 'debris' is used instead of the more common 'detritus' (Panikkar and Menon, 1956) since it was not known whether it was of organic or inorganic origin. It was not possible to decide whether the debris had been ingested as such or ground up in the stomach.

4.7 Miscellaneous items

This included various items, like foraminiferans (Pulvinulina sp.) and algal filaments which occurred in isolated cases.

Prawns are believed to be omnivorous in habit, feeding mostly over mud flats. Forster (1951) stated that since prawns can catch small amphipods and other crustaceans it may be that their habits are not so much scavenging as is commonly supposed. The preponderance of crustaceans and fishes in the diet of Solenocera indica may not be the result of scavenging activities alone. Kunju (1956) has observed seperate habits in aquarium reared Leptocarpus fluminicola. In the study of the feeding habits of S. subnuda, Hall (1962) found that polychaetes formed the dominant food item which were ingested by a definite process of selection.

5 MATURATION AND SPAWNING

Maturity stages in the female penaeids have been determined by different methods by various authors. King (1948) and Lindner and Anderson (1956) designated the various ovarian stages of Penaeus setiferus as "undeveloped", "developing", "yellow", "ripe" and "spent". Eldred et al. (1961) and Cummings (1961) classified the ovary of Penaeus duorarum into "undeveloped", "developed", "nearly ripe", and "ripe". Shaikhmahmud and Tembe (1961) used the terms "immature", "early maturing", "late maturing", "mature", and "spent", while differentiating the maturity stages of the ovary of Parapenaeopsis stylifera. The method adopted by Cheung (1963) was similar to that of Shaikhmahmud and Tembe, but he combined the "early" and "late maturing" stages into a single "maturing" stage. These stages were recognized by the various authors by taking into account both macroscopic and microscopic characters of the ovary and ovum.

In the present study the following stages were recognized.

(i) Immature: Ovary small, thin and colourless, not visible through the exoskeleton. Ovum transluscent and nucleus clearly visible; yolk granules sparsely distributed.

(ii) Maturing-early: Ovary opaque and from pale to bright yellow in colour; stil not visible through the exoskeleton. Nucleus only faintly visible through the yolk granules in the ovum.

(iii) Maturing-late: Ovary orange in colour, which is darker in advanced stages; visible through the abdominal tergites and the membraneous connectives between the first abdominal somite and the carapace. Ovum opaque, packed with yolk granules and nucleus not visible.

(iv) Mature: Ovary occupies all the available space in the abdomen and cephalothorax, dark brown in colour and clearly visible through the exoskeleton all along the abdomen. Surface of the ovum appears corrugated due to the presence of rod shaped peripheral bodies.

(v) Spent: Ovary greatly reduced in size, loose and flaccid in appearance, cream or dirty yellow in colour. As the spent stage advances the ovary is found further reduced in size, opaque and pale yellow in colour, rendering it difficult to be distinguished from the "maturing-early" stage. Under the microscope several disintegrating ova and myriads of follicle cells are visible.

Colour of the ovary in the various stages described pertained to preserved material as it was not possible to record it before preservation. Structure of the ovum was examined when gross macroscopic characters of the ovary failed to yield dependable clues to the precise maturity stage.

Since the smallest maturing female recorded was 51 mm (total length), sizes below this were excluded from the study. Incidence of the various maturation stages in the different months from October 1959 to July 1963 at each centre of observation was recorded. The material from Arnala was meagre and that from Sassoon Dock had only very few individuals with the ovary in different maturation stages. The Versova samples had a fair representation of all these stages (Table II). One or the other of the maturity stages was present in all the months and "mature" and "spent" conditions were found occurring together. The distribution of the various maturity stages among prawns collected from Versova in the different months is graphically shown in Fig. 1. Generally, there is a gradual decline in the incidence of the various stages from October onwards. Among the "maturing-early" stage there were two peaks, in October and February. These peaks were found progressing towards the spawning stage in December and April. The December to January peak of "mature" prawns was probably derived from the "maturing-early" peak of October, though the corresponding "maturing-late" stage was not clear. On the other hand, the "maturing-early" peak of February was found to pass through a well defined peak of "maturing-late" stage in March and attain the "mature" stage in April. The peaks formed by the "mature" and "spent" prawns were found in the same period. Among the "mature" prawns a good many may have been in such an advanced stage as to spawn immediately. It has been observed in other penaeids also that once the ovary reaches the "mature" stage spawning follows soon after (King, 1948; Cheung, 1963, and 1964).

It is evident that the prawn spawns throughout the period of the fishery, and has two peak spawning periods, in December and April (Fig. 1). In *S. subnuda* two peak spawning periods were observed, but in certain months there was a total absence of maturing stages (Cheung, 1963).

TABLE II

Occurrence of various maturity stages of *S. indica* at Versova

Month	Total No.	Spent	Mature	Maturing-Late	Maturing-Early	Immature
October 1959	34	1	3	14	10	6
November	58	5	11	21	13	8
December	65	5	8	15	16	21
January 1960	42	1	-	5	9	27
February	120	-	-	1	42	77
March	92	1	-	10	13	68
April	95	8	1	5	18	63
May	48	-	-	-	4	44
June	12	-	-	-	-	12
October	21	-	-	3	7	11
November	24	1	1	4	3	15
December	81	6	31	15	10	19
January 1961	92	5	21	9	11	46
February	98	6	5	21	15	51
March	68	2	-	10	13	43
April	65	2	5	12	9	37
May	50	-	1	2	8	39
October	5	-	-	-	2	3
November	91	1	10	12	17	51
December	60	2	4	11	10	33
January 1962	50	-	8	7	16	19
February	33	-	-	4	6	23
March	56	-	1	15	21	19
April	37	-	-	-	1	36
May	58	-	-	-	3	55
June	14	-	-	-	-	14
December	47	2	-	5	16	24
February 1963	69	-	-	3	23	43
March	82	1	4	12	12	53
April	63	2	2	4	12	43
May	79	2	-	-	10	67

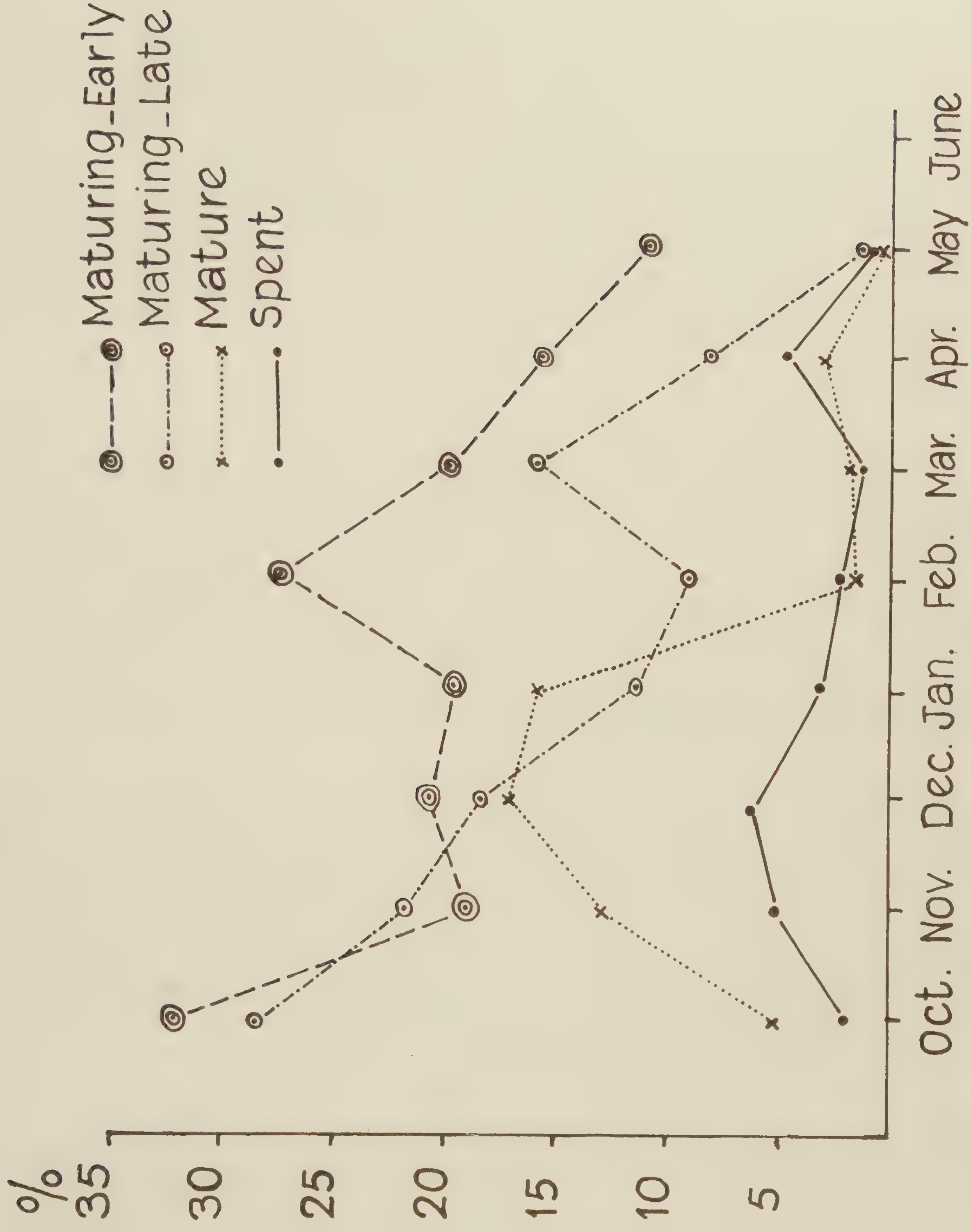

Fig. 1. Incidence of maturity stages of female S. indica in different months at Versova.

From the progression of modes described above (Fig. 1) it is seen that the "immature" prawns took about three months to attain the "mature" condition and eventually spawn.

There was a gradual reduction in the relative abundance of prawns in progressive conditions of maturity, from the "immature" to the "spent", the number of "spent" prawns being conspicuously low, compared to the other stages. In instances where spawning takes place within the fishing grounds the number of "spent" prawns encountered was far greater than observed in the present species (Cheung, 1963 and 1964; Lindner and Anderson, 1956; Eldred *et al*., 1961), especially in the peak spawning periods. Therefore, it is possible that the main spawning ground of *S. indica* is not within the fishing area from where the material was collected. Nevertheless, the occurrence of "spent" prawns in the catches, although not in large numbers, may indicate that the fishing area is probably contiguous with the main spawning ground of the prawn. This assumption is further supported by the fact that "mature" and "spent" prawns were rarely encountered at Sassoon Dock where fishing is carried out within 20 m depth, whereas the 'dol' fishery at Versova and Arnala, where the fishing grounds lie within 30 to 40 m depth yielded larger proportions of these stages.

6 MIGRATION

Two types of migratory movements were discernible in *S. indica*, one in connection with spawning and the other in relation to salinity. As stated earlier the presence of such a small number of "spent" prawns would indicate that the females move out of the fishing grounds for spawning. Males probably do not participate in this migration, *vide infra*. Besides, the gradual decrease in the number of individuals in advanced stages of maturity could also be due to such a movement. How far out the prawn migrates and its further destiny is not known. As explained in connection with the incidence of "spent" stages, the spawning migratory movement was towards an area closely adjacent to the fishing grounds thus indicating a limited spawning migration, similar to that of *S. subnuda* (Cheung, 1963). These migrations were found to take place throughout the year, with two peak periods in December and April. In the length frequency studies (see below) the larger size groups were found to disappear from the exploited area in regular progression and these groups constituted the breeding females which were migrating away from the fishing grounds.

The second migratory movement was found to take place when the population *en masse* moved offshore when the salinity of the coastal waters decreased from June to early October as a result of the southwest monsoon rains. Jayaraman *et al*. (1961) recorded the lowest salinity conditions in Bombay in these months. During this period fishing activities were entirely suspended at Versova, but the 'dol' fishery at Sassoon Dock and the 'bokshi' fishery at Arnala were continued uninterrupted (Kunju, 1967). In the latter two *S. indica* was completely absent in these months. As in the spawning migration it is likely that the prawn moves out only to adjacent areas of higher salinity. Trawl catches taken from within 40 m depth usually contained a small number of large sized *S. indica* which were altogether absent in the monsoon months. A sciaenid fish (*Otolithoides brunneus*) caught off Bombay, in August 1960, in a depth of about 60 m was found to have fed on *S. indica*.

7 EFFECT OF TEMPERATURE AND SALINITY ON SPAWNING AND MIGRATION

In certain penaeid prawns, Cummings (1961) and Eldred *et al*. (1961) found a direct relation between salinity and temperature on one hand and spawning and migration on the other. The period of low salinity in the surface waters of Bombay was recorded as from June to October, the salinity ranging from 23 to 27 $o/_{oo}$, whereas in the other months it was between 35 and 37 $o/_{oo}$ (Jayaraman *et al*., 1961). It is when the salinity begins to fall on the onset of the southwest monsoon rains that *S. indica* migrates *en masse*, to return to the fishing grounds in October when the pre-June salinity is restored. Though there is a slight decline in the temperature also in these months, it does not appear significant.

In the peak spawning months of December and April the temperature is relatively low (25 to 26°C) in the former and high (29 to 31°C) in the latter month (Jayaraman et al., 1961) indicating that spawning does not probably depend on temperature conditions. But both these peak periods coincide with the period of highest salinity of 35 to 37 $o/_{oo}$ in the surface waters.

8 RELATIONSHIP BETWEEN TOTAL LENGTH AND CARAPACE LENGTH

Several early workers considered total length, from the tip of rostrum to the ti of telson, as the most reliable measure of size in prawns, while Burkenroad (1934; 1951) contended that length did not reveal certain important increases in size, and that volume or weight should be used. Kubo (1949; 1956), Dall (1958) and Cheung (1963; 1964) have been using carapace length in assessing growth and other characteristics of the prawn. In the present investigation total lengths alone were recorded, from which length frequency studies were made, and carapace lengths of 255 prawns, collected in 1965, were recorded in order to determine the relationship between these two measurements.

Carapace measurements were grouped in 1.0 mm classes and their averages were plotted against average total lengths. A straight line fitted by the method of least squares gave a good fit (Fig. 2). The relationship was found to be

$$L = 6.91 + 3.20\ C$$

where L is the total length (mm) and C the carapace length (mm)

9 LENGTH FREQUENCY STUDIES

Size frequency studies were based on samples collected from Versova from October 1959 to April 1965. The frequency groups for males were represented by sharp peaks owing to their small size range, while those for females were more flattened. The frequencies for the period October 1964 to April 1965 are shown in Fig. 3. The modes, exhibited by both the sexes, were in many places rather obscure and hence drawing conclusions on these was rendered difficult. However, certain definite trends in the progression of several series of modes were found significant (Table III).

The rates of growth of penaeid prawns vary in different species. In Metapenaeus dobsoni it was 4 to 14 mm (Menon, 1952), in M. bennettae (as M. mastersii) 10 mm (Dall, 1958) and in M. monoceros 5 to 10 mm (George, 1959). The averages derived from modal progressions of prawns of 33 mm and above in length (Table III) showed that the monthly growth of S. indica was 6.96 mm in females and 6.49 mm in males, which is about the same reported for S. subnuda (Cheung, 1963).

Recruitment of juveniles of both the sexes measuring 33 mm and less was evident in the months of January to March every year, and probably they were the progeny of the spawning group of November to December. Therefore, they may be 2 to 3 mo old having grown at a faster rate than those of over 33 mm length. The generation derived from the second spawning peak in April was not represented in the length frequency graphs, since by June the fishery at Versova was suspended.

The largest female and male encountered during this study measured 114 mm and 80 mm respectively, and taking into consideration the monthly average growth and the approximate age of the juvenile recruits discussed above, these prawns may be 14 to 15 and 9 to 10 mo old respectively.

As the smallest female found with "maturing-early" ovary was 51 mm it may probably attain this stage when it is 5 to 6 mo old. Since the immature ovary takes about 3 mo to attain the spawning stage, the prawn may spawn for the first time when it is 8 to 9 mo old. This inference is further supported by the fact that the majority of spent females were within 81 to 85 mm length (Table IV) and by the method of estimate

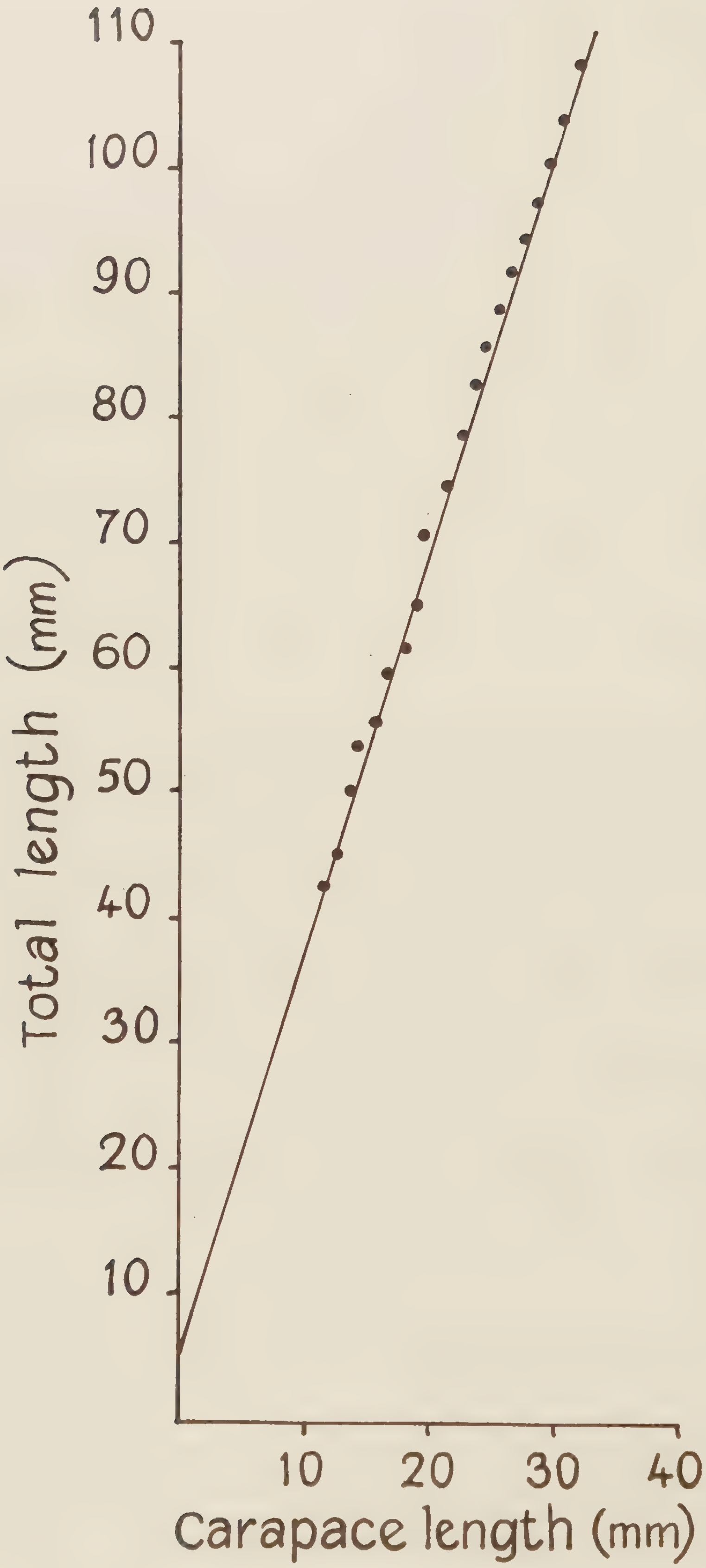

Fig. 2. Relationship between total length and carapace length of S. indica.

TABLE III

Progression of modes from length frequency polygons
of *S. indica* from Versova

Female					
From		To			
Month	Mode (mm)	Month	Mode (mm)	Growth (mm)	Period in months
October 1959	38	June 1960	93	55	8
October	58	March	93	35	5
October	78	January	98	20	3
January 1960	48	May 1960	78	30	4
October	48	March 1961	88	40	5
October	63	March	98	35	5
November	38	May	88	50	6
January 1961	33	May 1961	63	30	4
November	48	April 1962	88	40	6
October	58	March	93	35	5
December	33	June	73	40	6
December 1962	63	April 1963	88	25	4
December	53	May	88	35	5
February 1963	48	May 1963	73	25	3
February	33	May	58	25	3
October	53	April 1964	88	35	6
December	43	May	63	20	4
February 1964	33	May 1964	53	20	3
October	68	April 1965	108	40	6
October	43	April	83	40	6
Average growth of female per month = 6.96 mm					

Male					
From		To			
Month	Mode (mm)	Month	Mode (mm)	Growth (mm)	Period in months
October 1959	43	December 1959	58	15	2
December	43	March 1960	63	20	3
January 1960	38	May 1960	58	20	4
November	38	February 1961	58	20	3
January 1961	33	May 1961	58	25	4
October	43	December	58	15	2
February 1962	33	May 1962	58	25	3
February 1963	38	May 1963	58	20	3
December	43	February 1964	58	15	2
February 1964	33	May 1964	53	20	3
March	53	May	63	10	2
October	48	January 1965	63	15	3
January 1965	38	April 1965	58	20	3
Average growth of male per month = 6.49 mm					

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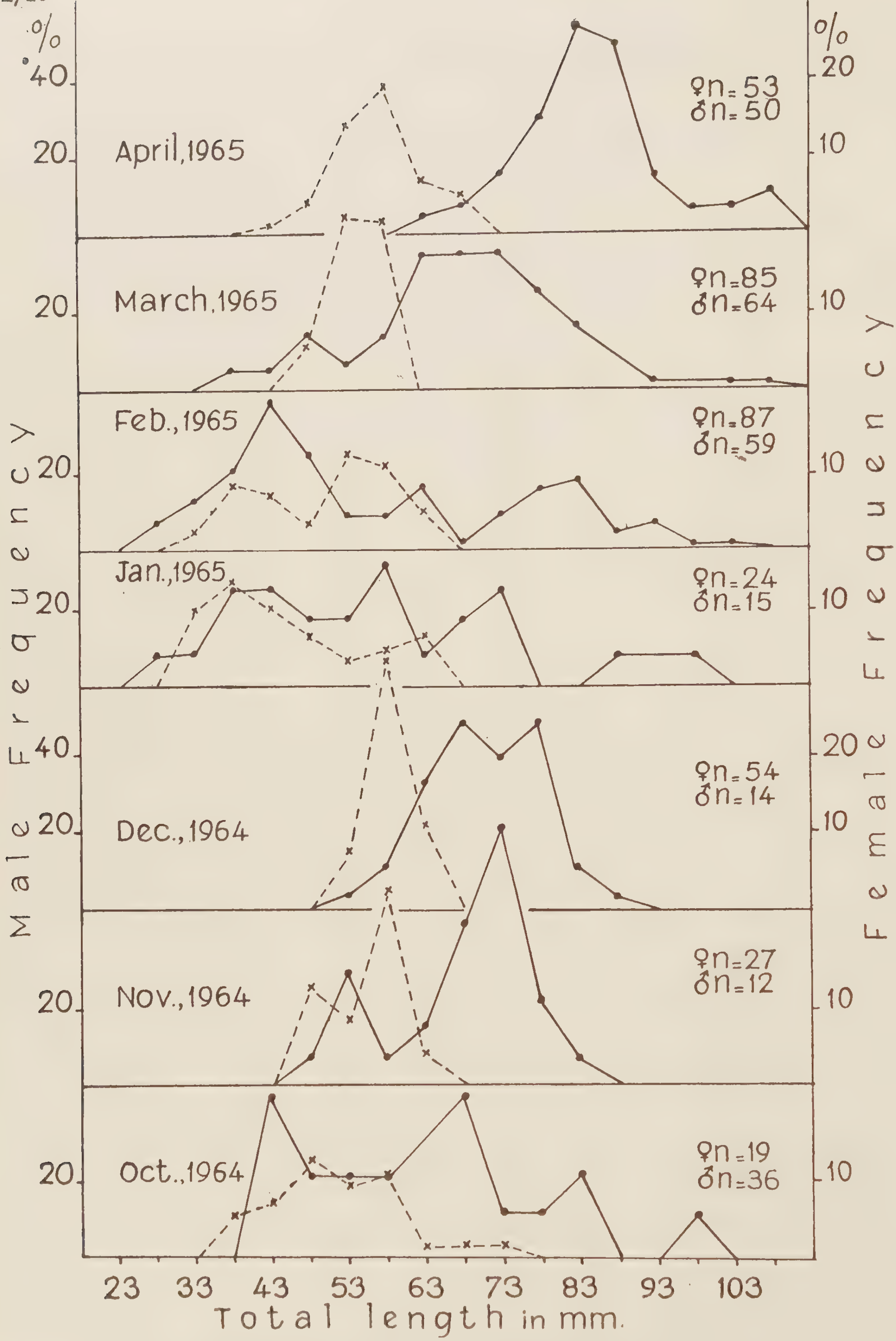

Fig. 3. Length frequency distribution of S. indica from October 1964 to April 1965 at Versova.

shown above they are approximately 9 mo old. As the life span of the female was estimated to be approximately 14 to 15 mo it is possible for the prawn to spawn at least once again; but, in the absence of other evidence this inference can only be tentative.

TABLE IV

Distribution of the various maturity stages of S. indica among the different size groups from all the centres

Size group (mm)	Total No.	Spent	Mature	Maturing-Late	Maturing-Early	Immature
51- 55	330	-	-	8	3	319
56- 60	349	-	-	9	8	332
61- 65	335	-	8	15	22	290
66- 70	403	3	17	42	63	278
71- 75	395	11	22	46	85	231
76- 80	395	8	28	48	93	218
81- 85	289	20	20	49	74	126
86- 90	260	12	28	37	79	104
91- 95	104	5	6	30	35	28
96-100	44	2	6	10	18	8
101-105	12	1	-	6	1	4
106-110	3	-	1	-	1	1
111-115	2	-	1	-	-	1

10 SEX RATIO

The female-male ratio in the population varied from month to month (Table V) but with the females always dominating. The disparity between the sexes was least in the month of October and high in the months of January, April and May when more than half the population was constituted by females. A breakdown of the data for the entire period of investigation showed that the number of females was twice that of males (Table V).

The sex-wise size distribution of the prawn for the entire period is shown in Fig. 4. Up to about 48 mm size the disparity between the sexes is not pronounced, whereas from this stage onwards there is a striking preponderence of males in the population, which is probably because the sexually maturing females move out of the fishing grounds. Therefore it is possible that mating and impregnation take place within the fishing grounds only and that the males do not move out of the grounds along with the

TABLE V

Sex-wise size distribution of *S. indica* in different months in all the centres

Size group	October		November		December		January		February		March		April		May		All months	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
21- 25	-	-	1	1	-	-	-	1	2	-	10	5	1	1	2	-	16	8
26- 30	3	-	11	2	9	4	3	4	19	6	34	16	6	5	1	-	86	37
31- 35	7	1	13	8	13	9	18	4	36	17	32	13	15	6	3	3	137	61
36- 40	24	7	39	14	30	17	21	8	44	39	44	23	49	14	9	4	260	126
41- 45	35	19	19	35	51	41	53	22	73	53	75	26	58	19	17	9	381	224
46- 50	27	50	35	69	49	74	37	26	96	77	109	85	69	27	32	9	454	417
51- 55	29	54	37	70	65	91	45	83	76	149	99	183	73	91	36	31	460	752
56- 60	41	53	50	63	70	89	40	76	64	169	103	106	67	78	52	70	487	704
61- 65	36	20	60	29	74	40	37	18	63	48	103	42	58	28	57	40	488	265
66- 70	31	10	75	6	89	6	68	9	75	5	99	9	61	8	64	14	562	67
71- 75	14	5	61	1	79	-	71	-	84	-	108	2	73	-	52	-	542	8
76- 80	16	1	47	-	62	-	61	-	81	1	98	-	79	-	70	-	514	2
81- 85	19	-	46	-	43	-	34	-	71	-	70	-	59	-	40	-	382	-
86- 90	11	-	33	-	31	-	22	-	46	-	58	-	65	-	57	-	323	-
91- 95	3	-	12	-	12	-	5	-	24	-	33	-	14	-	20	-	133	-
96-100	-	-	12	-	9	-	3	-	5	-	9	-	9	-	12	-	59	-
101-105	1	-	3	-	2	-	1	-	3	-	4	-	-	-	2	-	16	-
106-110	-	-	2	-	-	-	-	-	-	-	2	-	2	-	1	-	7	-
111-115	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Total	297	220	556	298	688	371	520	251	862	564	1,090	510	758	277	527	180	5,308	2,671

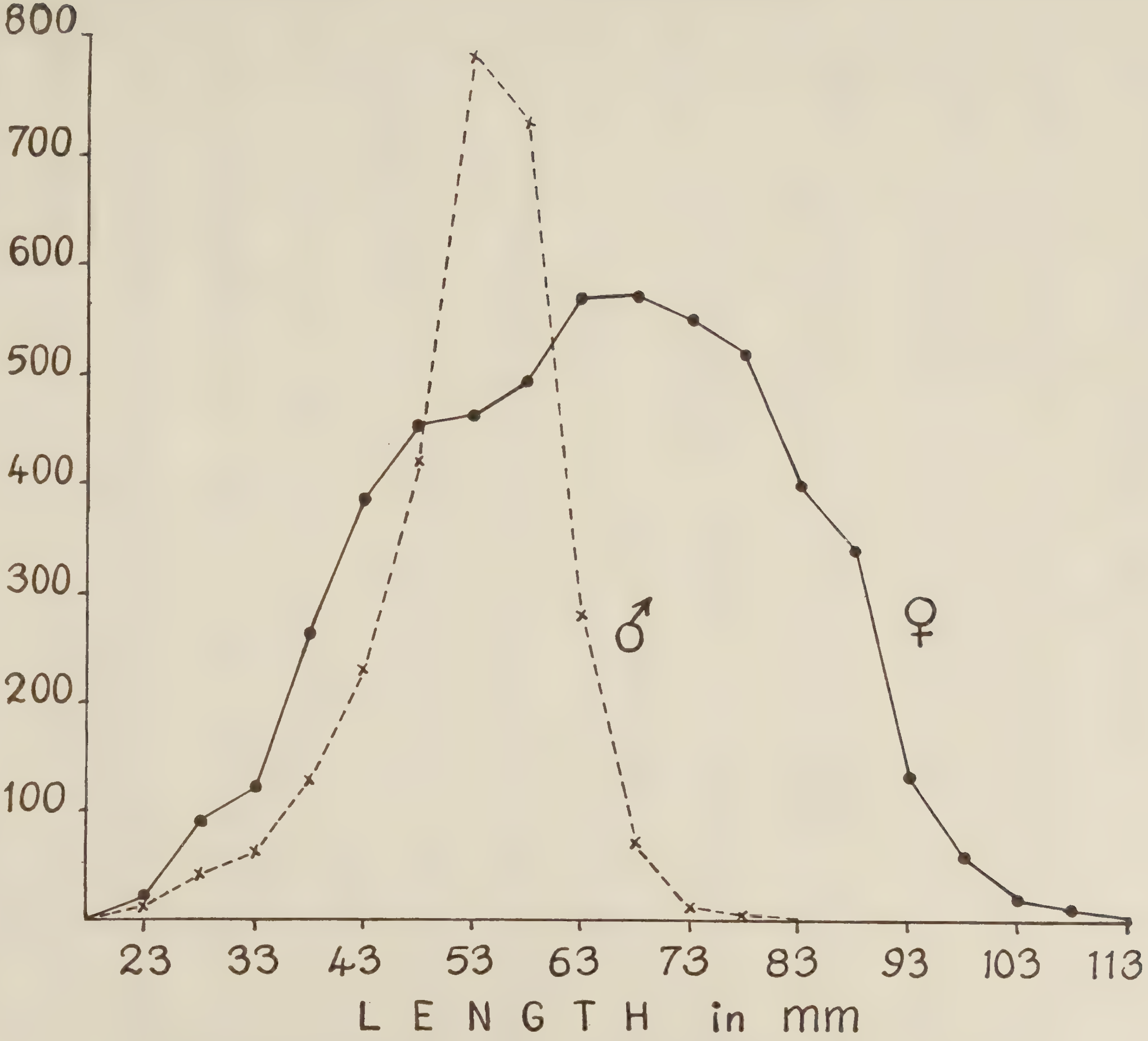

Fig. 4. Size frequency of female and male *S. indica* for the entire period from October 1959 to April 1965 from all the centres.

females. The disparity seen in the higher size groups could be only due to the shorter length attained and the comparatively short life span of the male. Menon (1957) suggested that the disparity in the sexes of older size groups of four penaeid species he studied, viz. *Metapenaeus dobsoni*, M. *monoceros*, *Penaeus indicus* and *Parapenaeopsis stylifera* was due to their inshore and offshore migrations.

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POSTLARVAE OF PENAEID PRAWNS OF SOUTHWEST COAST OF INDIA WITH A KEY TO THEIR IDENTIFICATION

by

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Abstract

The first postlarvae of five commercially important penaeid prawns of the southwest coast of India, viz., *Penaeus indicus*, *Metapenaeus monoceros*, *M. affinis*, *M. dobsoni* and *Parapenaeopsis stylifera*, are described. A comparison of their diagnostic features and a key for their identification are given together with notes on distribution and swimming behaviour.

POSTLARVES DE PENAEIDAE DE LA COTE SUD-OUEST DE L'INDE ET CLEF POUR LEUR IDENTIFICATION

Résumé

La communication décrit les premières postlarves de cinq Penaeidae d'importance commerciale de la côte sud-ouest de l'Inde : *Penaeus indicus*, *Metapenaeus monoceros*, *M. affinis*, *M. dobsoni* et *Parapenaeopsis stylifera*. Elle compare leurs caractéristiques et fournit une clef pour leur identification, ainsi que des notes sur la répartition et le comportement en matière de nage.

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POST-LARVAS DE PENEIDOS DE LA COSTA SUDOCCIDENTAL DE LA INDIA CON UNA CLAVE PARA SU IDENTIFICACION

Extracto

Se describen las primeras post-larvas de cinco especies de peneidos comercialmente importantes de la costa sudoccidental de la India, a saber: *Penaeus indicus*, *Metapenaeus monoceros*, *M. affinis*, *M. dobsoni* y *Parapenaeopsis stylifera*. Se hace una comparación de sus características distintivas y se da una clave para su identificación, junto con algunas notas sobre su distribución y comportamiento natatorio.

1 INTRODUCTION

The commercial fisheries for penaeid prawns of the southwest coast of India are supported by several species that often occur simultaneously. It is a known fact that these prawns breed in the sea and their planktonic larvae enter the estuaries and backwaters as they transform into late mysis or postlarval stages. The establishment of the correct identity of the postlarval forms of each of the constituents of this multispecies fishery is essential in order to understand the dynamics of the juvenile and adult populations. This is particularly so, when the juveniles as well as adults are subjected to commercial exploitation. Differentiation of these developing stages into their respective species has been rendered difficult owing to their apparent similarities in shape, size and habits.

Information on the larval and postlarval stages of Indian penaeids is limited to the descriptions of a few early stages of *Penaeus indicus* (Menon, 1937; Subrahmanyam, 1965) and complete larval history of *Metapenaeus dobsoni* (Menon, 1951). George (1962; 1963) has studied the postlarvae of three species from Cochin backwaters and suggested the use of postlarval abundance as an index for predicting the magnitude of the trawl fishery. In view of the importance of the differentiation of these co-existing species in the study of the larval population, an attempt is made here to make a comparative description of the first postlarval stages of five important species viz., *Penaeus indicus*, *Metapenaeus monoceros*, *M. affinis*, *M. dobsoni* and *Parapenaeopsis stylifera*.

2 MATERIAL AND METHODS

Regular bi-weekly plankton collections were made off Cochin Bar mouth and from the adjoining backwaters. The plankton tows were of 10 min duration, generally made with an organdy net of half a metre diameter during the early hours of the morning at subsurface waters. In the laboratory the postlarvae were sorted out and examined live for colouration and behaviour, and then preserved in 5 percent formaldehyde for further studies. Late mysis stages of some of the species were reared in the laboratory to the subsequent stages.

3 FIRST POSTLARVA

Late mysis stage metamorphoses into the first postlarva. The salient feature of this stage is the taking over of locomotory function by the pleopods and this is accomplished with the development of setae on pleopods and loss of exopodites on the pereiopods. Other morphological changes include loss or reduction of median dorsal spines on the abdominal segments and development of a conspicuous forwardly directed spine on the midventral aspect of the 7 to 8 thoracic somite.

3.1 *Penaeus indicus* H. Milne Edwards (Fig. 1)

Although different stages of the postlarvae were encountered in all the collections, the earliest stage was obtained only from the offshore collections. They are relatively few in number and their sizes range from 5.22 to 5.95 mm in total length [1] and 1.28 to 1.35 mm in carapace length.

Carapace: Rostrum bears a single tooth and slightly exceeds the eye. A small supraorbital spine present, but the anterolateral angle of the carapace is devoid of any spine. Hepatic spine well developed.

Antennule: Peduncle 3-segmented, with well developed statocyst at the base. The proximal segment longest; the inner branch of the distal segment 3-jointed, while the outer is only 2-jointed.

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[1] Total length is from tip of rostrum to posterior end of telson excluding spines

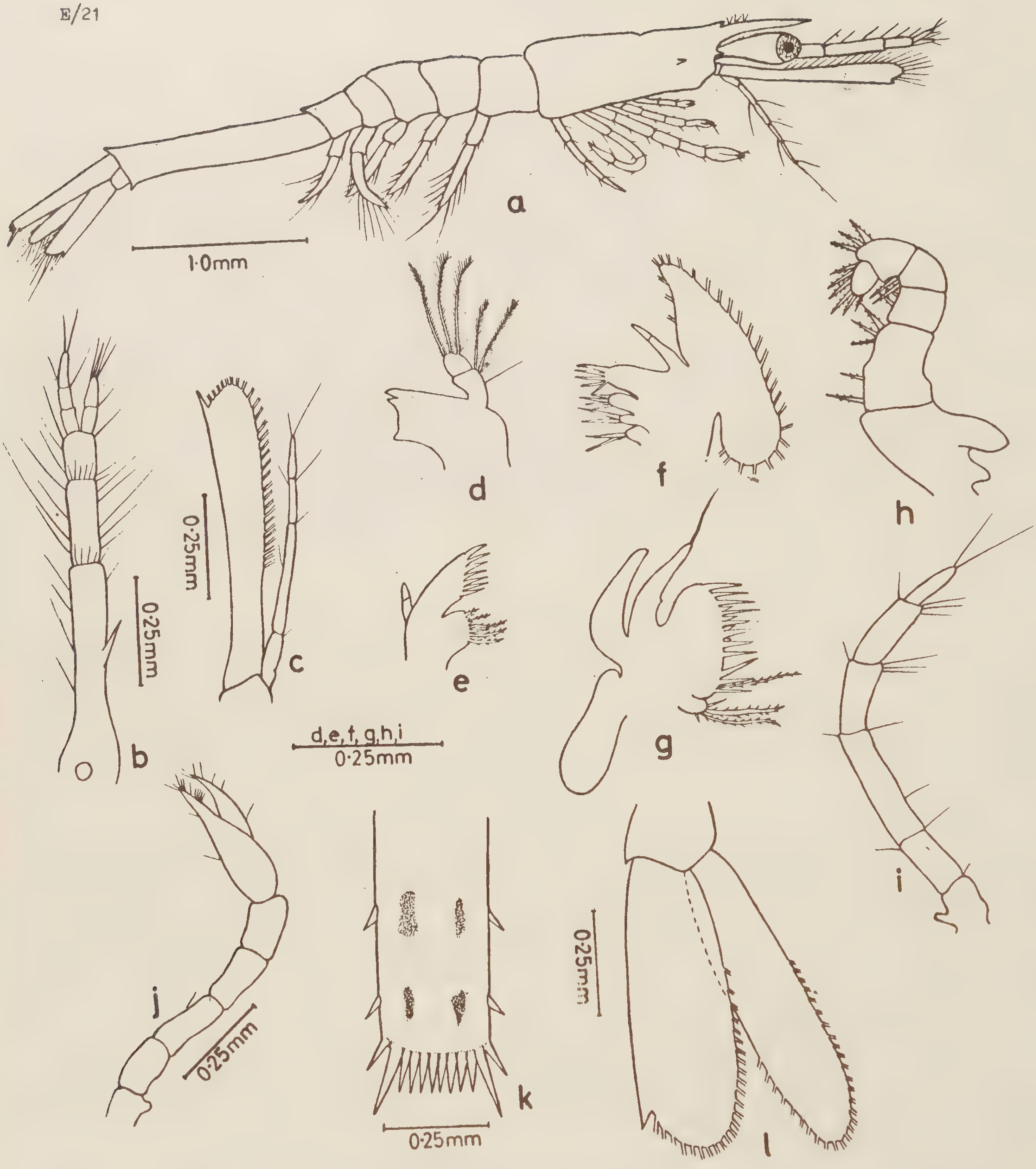

Fig. 1 *Penaeus indicus*, first postlarva (a) Lateral view. (b) Antennule. (c) Antenna. (d) Mandible. (e) Maxilla I. (f) Maxilla II. (g) Maxilliped I. (h) Maxilliped II. (i) Maxilliped III. (j) First pereiopod. (k) Telson. (l) Uropod.

Antenna: Flagellum 4-jointed and about 3/4 length of the scale. Scale with well developed anterolateral spine projecting slightly beyond the tip and with 28 plumose setae.

Mandible: Mandibular palp well developed and jointed; the outer border of both segments beset with setae.

Maxilla I: The endopod small, 2-segmented and without setae, its line of demarcation from the peduncle faintly visible.

Maxilla II: The endopod has 4 functional endites; the palp is faintly segmented near the tip and provided with 2 minute setae. Scaphognathite very conspiouous and with 27 plumose setae.

Maxilliped I: Very much reduced; peduncle wide and 2-segmented with numerous setae along inner margin. Exopod and endopod unjointed, the former non-setose and the latter with a single terminal seta. Epipodite well developed.

Maxilliped II: Protopod with a gill; exopod rudimentary; endopod 5-segmented with the distal 3 segments curved inward.

Maxilliped III: Vestigial exopod present; endopod 5-segmented.

Pereiopods: First 3 pairs chelate, 3rd pair the longest. Each chelate leg has 2-jointed protopod and an endopod of 5 segments. The 4th and 5th pairs non-chelate, but having the same number of segments as the first 3 pairs.

Pleopods: Uniramous, first 3 pairs well developed and longer than the last 2. Each pleopod 3-jointed with the distal segment bearing 10 setae.

Abdomen: Median dorsal spine present on 5th and 6th abdominal segments. Anal spine present.

Telson: Bears 3 pairs of lateral and 5 pairs of terminal spines.

Uropod: Well developed, with a large spine on the externodistal border of the exopod which possesses 25 marginal setae. The endopod fringed with 29 to 30 setae.

Colouration (Fig. 6a): Tips of 2nd and 3rd segments of antennular peduncle light reddish; eye stalk yellowish. Middle region of the carapace and the 2nd, 3rd and 4th abdominal segments slightly yellowish and with a few branched brownish red chromatophores. The distal end of the last thoracic somite as well as proximal portion of the tail fan yellowish and with red pigmentation. Distal end of telson also possesses reddish brown chromatophores.

Swimming behaviour: Fast swimmers, seen to perform rapid forward movement along the edges of the container and surface, often trying to jump out of the water when disturbed.

3.2 Metapenaeus monoceros (Fabricius) (Fig. 2)

First postlarval stage was obtained from both marine and backwater collections, the former containing more early stage larvae. A few larvae were also obtained by rearing late mysis stage. Their size range varied from 3.75 to 3.95 mm total length and 1.104 to 1.112 mm carapace length.

Carapace: Rostrum small, not quite reaching middle of eye stalk, tip pointed and appears triangular; bears 2 principal teeth, the first arising at the level of the anterior border of carapace and the second considerably posterior to it. The first has a smaller tooth in front and the second, larger tooth is followed by a much smaller spine. A conspicuous antennal and a smaller hepatic spine present. Pterygostomial spine absent.

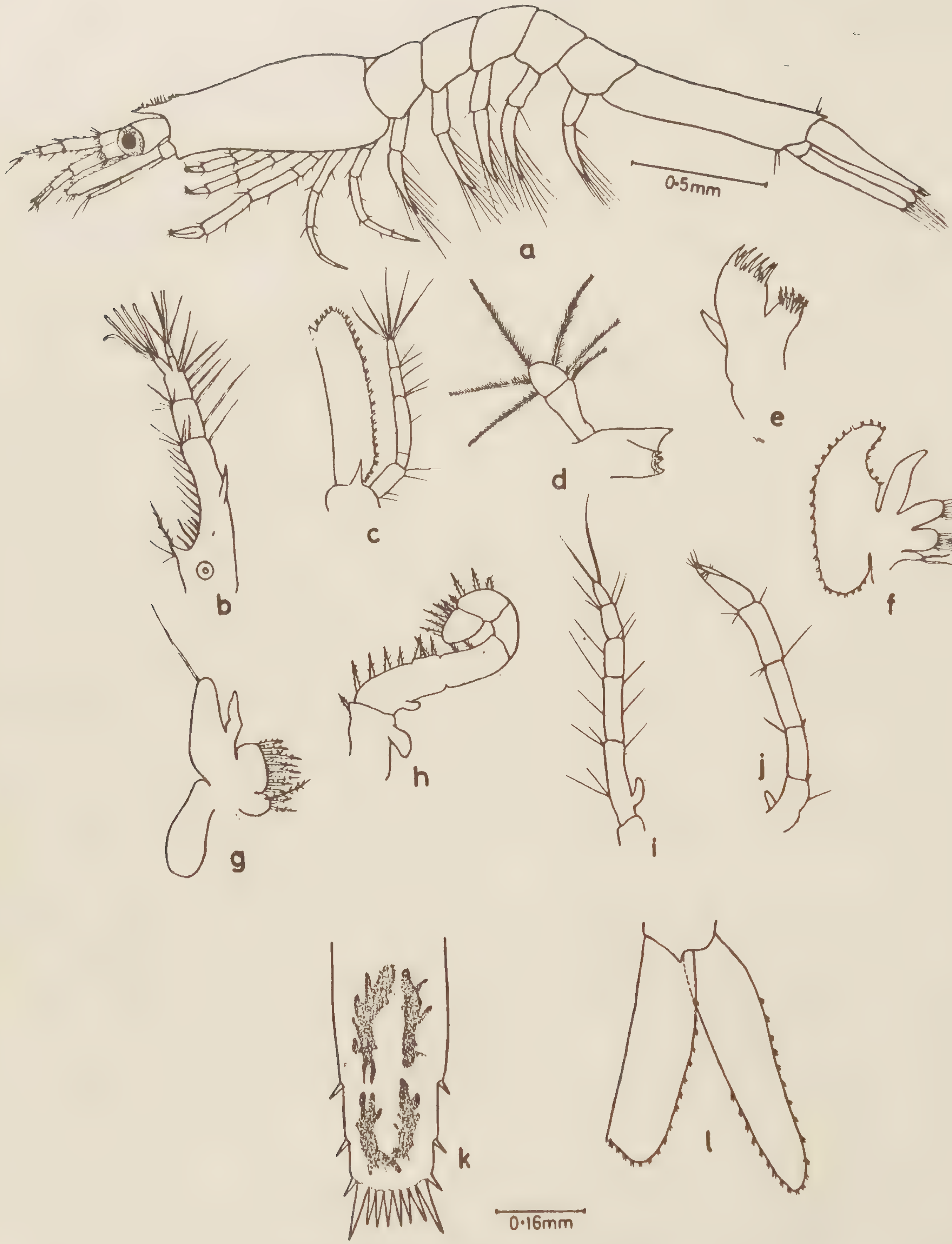

Fig. 2 *Metapenaeus monoceros*, first postlarva. (a) Lateral view. (b) Antennule. (c) Antenna. (d) Mandible. (e) Maxilla I. (f) Maxilla II. (g) Maxilliped I. (h) Maxilliped II. (i) Maxilliped III. (j) First pereiopod. (k) Telson. (l) Uropod.

Antennule: Peduncle 3-segmented, proximal segment being the longest. A well developed statocyst present at the base, the top of the statocyst swelling bearing 5 hairs as in Metapenaeus bennettae (as M. mastersii) (Muriel and Bennett, 1951). The inner branch of the 3rd segment 2-jointed, carrying 4 setae at the tip and the outer branch faintly segmented with 5 to 6 aesthetes. Ventral spine present.

Antenna: Spine on the protopodite well developed; flagellum 4 to 5 jointed, 5 setae on the distal segment which reaches 3/4 length of the scale. Scale with 26 setae and an anterolateral spine which falls short of the anterior margin of the scale.

Mandible: Palp well developed, segmented, bearing 6 setae.

Maxilla I: Endopod unjointed, small and without setae.

Maxilla II: Only 3 functional endites; palp unsegmented and the scaphognathite with 32 plumose setae.

Maxilliped I: Very small in size; peduncle 2-segmented with numerous setae on its inner margin; exopod and endopod unjointed, the former with a single terminal seta and the latter non-setose. Epipodite present.

Maxilliped II: Vestigial exopod and a small epipodite present. Endopod 5-segmented and bent inward at the distal portion.

Maxilliped III: Exopod vestigial present as a small bud on the base; endopod 5-segmented.

Pereiopods: Each 5-segmented and beset with small setae; 3rd pair of the first 3 chelate legs the longest. First pereiopod with a minute basial and ischial spine; 3nd and 3rd with basial spine only.

Pleopods: Uniramous, 3-segmented, the distal segment bearing 10 setae.

Abdomen: None of the abdominal segments except the 6th has a median dorsal spine. Anal spine present. The lateral aspect of the distal portion of the 6th segment carries 2 to 3 pairs of long setae.

Telson: With 2 pairs of spines on the lateral margin and 5 pairs posteriorly.

Uropod: Exopod with 17 setae and a minute spine on the anterodistal border. Endopod narrower than exopod and with 22 setae.

Colouration (Fig. 6b): The postlarva can be readily spotted in the plankton due to its brownish appearance to the naked eye. The whole antennular peduncle is covered with reddish pigments. The carapace is provided with a number of branched chromatophores. The ventral side of the abdomen is profusely pigmented with arborescent reddish chromatophores, as a result of which the whole abdomen appears brownish red. Under the microscope each segment is seen to bear 3 or 4 branched chromatophores on either side Almost the entire telson is pigmented with reddish chromatophores.

Swimming behaviour: Swims straight in a forward direction without any jerk and rests horizontally on the edges of the container or at the surface. This habit and its conspicuous colouration make it easy to be spotted in the plankton.

3.3 Metapenaeus affinis (H. Milne Edwards)(Fig. 3)

The postlarvae of this species are relatively few in the collections. The material described was obtained by rearing the late mysis stage in the laboratory. Sizes ranged from 3.85 to 3.95 mm total length and 1.168 to 1.170 mm carapace length.

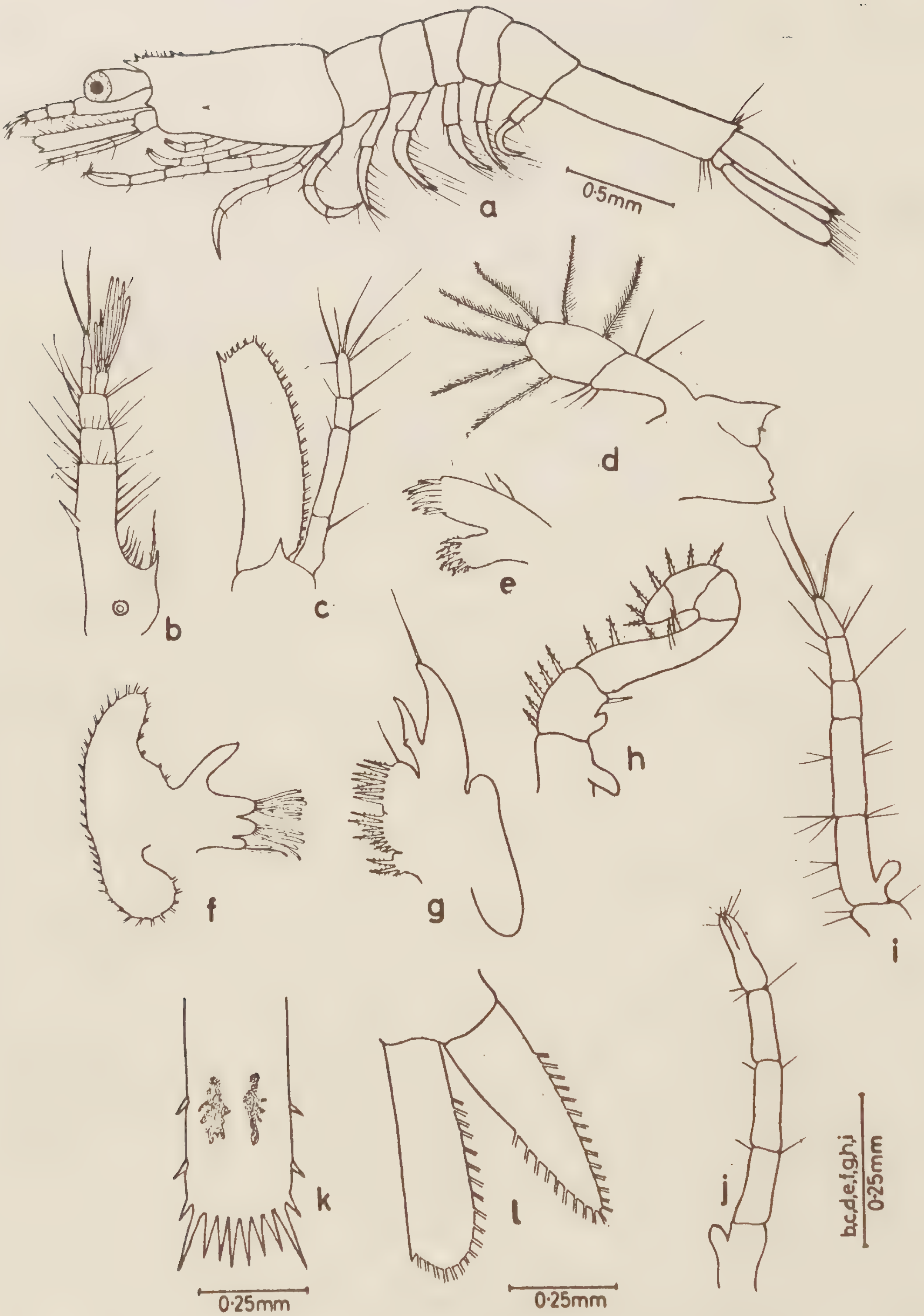

Fig. 3 Metapenaeus affinis, first postlarva. (a) Lateral view. (b) Antennule. (c) Antenna. (d) Mandible. (e) Maxilla I. (f) Maxilla II. (g) Maxilliped I. (h) Maxilliped II. (i) Maxilliped III. (j) First pereiopod. (k) Telson. (l) Uropod.

Carapace: Rostrum very small, projecting a little beyond the frontal border of the carapace, rostral tip triangular, and dorsally toothed. Just behind the tip there is a tooth which is followed by a minute spine. Posterior to this, there is another pair of spines, the anterior of which is larger. In addition and posterior to these the dorsal margin carries another tooth which probably represents the epigastric tooth, posterior to which one or two minute spines are also present in some of the specimens. Carapace with well developed antennal and hepatic spines, the anterolateral angle being smooth.

Antennule: Peduncle 3-segmented with a conspicuous statocyst at the base. 5 small stout hairs present on top of the statocyst swelling. Both inner and outer branches of the distal segment faintly jointed, the former carrying 3 setae at its tip and the latter with 6 to 8 aesthetes. Ventral spine present.

Antenna: Protopodite bears a small spine. Flagellum almost equal or slightly shorter than the scale and 4-jointed, the distal joint carrying 6 setae. Scale with well developed spine on the externodistal border, reaching almost the tip of the scale which is provided with 26 plumose setae.

Mandible: Palp jointed and the distal segment carries 7 to 8 plumose setae; 4 setae on the proximal segment.

Maxilla I: Endopodite small, unjointed and without setae.

Maxilla II: As in M. monoceros 3 functional endites present; palp unjointed and unarmed. Scaphognathite well developed and bearing 39 setae along its outer border.

Maxilliped I: Same as in M. monoceros.

Maxilliped II: Vestigial exopod and an epipodite present; endopod 5-segmented and tip curved as in M. monoceros.

Maxilliped III: Vestigial exopod present; endopod 5-segmented.

Pereiopods: First 3 pairs chelate as in other penaeids. Basial and ischial spines absent on first pereiopod.

Pleopods: Uniramous and functional, 3-segmented, distal segment with 10 to 11 long plumose setae.

Abdomen: Median dorsal spine on 6th abdominal segment only. The lateral aspect of the distal portion of the 6th segment carries more than 3 pairs of long setae. Small anal spine present.

Telson: As in M. monoceros there are 2 pairs of lateral and 5 pairs of posterior spines.

Uropod: Endopod with 24 and exopod with 19 setae. Spine on externodistal border conspicuous.

Colouration (Fig. 6c): Tips of the segments of the antennular peduncle pigmented. Eye stalk yellowish. Carapace and abdominal segments provided with branched dark chromatophores, but much less in density than in M. monoceros. In the telson, the chromatophores are distributed in patches in between the 2 pairs of lateral spines.

Swimming behaviour: Show slight jerking or springing movement. Rest along the edges of the container, mostly orientated towards areas of intense light, their bodies more or less parallel to the sides of the container with tail portion raised and head somewhat bent down. When disturbed they perform a sort of rotatory movement and then come to occupy the original 'resting' position.

3.4 Metapenaeus dobsoni (Miers) (Fig. 4)

This is by far the most abundant larva in the collections, and is equally distributed in the marine and backwater plankton. The first postlarvae were also obtained by rearing in the laboratory. Their sizes ranged from 3.0 to 3.50 mm total length and 0.928 to 0.975 mm carapace length.

The material on hand agrees in all essential characters with the descriptions of same stages given by Menon (1951). However, slight variations noticed in certain characters and a few additional features are shown in Fig. 4.

Colouration (Fig. 6d): Almost similar to that of M. affinis. Tips of 2nd and 3rd segments of antennular peduncle slightly brownish. Eye stalk yellowish. The abdominal segments appear light yellowish and each segment is provided with a branched dark chromatophore. There is also a patch of this chromatophore in the middle region of the telson.

Swimming behaviour: Show same movements and resting position as M. affinis.

3.5 Parapenaeopsis stylifera (H. Milne Edwards) (Fig. 5)

The postlarvae of this species were collected in very small numbers from the marine plankton only. They were also reared in the laboratory from the mysis stage. Sizes ranged from 4.25 to 4.75 mm total length and 1.290 to 1.315 mm carapace length.

Carapace: Rostrum lanceolate, reaching almost middle of eye stalk and with 2 dorsal spines, the posterior of which arises at the level of the frontal margin of the carapace. An epigastric spine also present. Carapace has well developed antennal and small hepatic spine. Branchiostegal spine broadly pointed and placed near the antero-inferior angle of the carapace. The region behind this spine is beset with 9 to 10 small setae.

Antennule: Peduncle 3-segmented as in other penaeids and with a median ventral spine on the basal segment. Statocyst well developed and the top of its swelling carries 6 small and stout setae and 1 long bipectinate seta. The outer branch of the 3rd segment is 3-jointed and the inner 5-jointed, the distal segment of which carries 6 setae.

Antenna: Flagellum long with 10 segments. Scale reaching tip of the third segment of the antennular peduncle and with a conspicuous spine on the antero-lateral border, not reaching the tip of the scale which is acutely rounded. Scale with 39 setae.

Mandible: Palp segmented, the proximal segment 1/5 the size of the distal which carries 25 to 26 setae.

Maxilla I: Very much reduced; endopodite unjointed and without seta.

Maxilla II: With 4 functional endites, the proximal of which is without setae. Palp unsegmented; the scale very large with the whole border beset with 54 to 55 setae.

Maxilliped I: Endopod and exopod not segmented, but with a few setae at their tips. Epipodite present.

Maxilliped II: Vestigial exopod present; the endopod similar to that of other larvae described above.

Maxilliped III: Endopod 5-segmented; vestigial exopod present.

Pereiopods: First three legs chelate, the 3rd the longest reaching to middle of antennal scale.

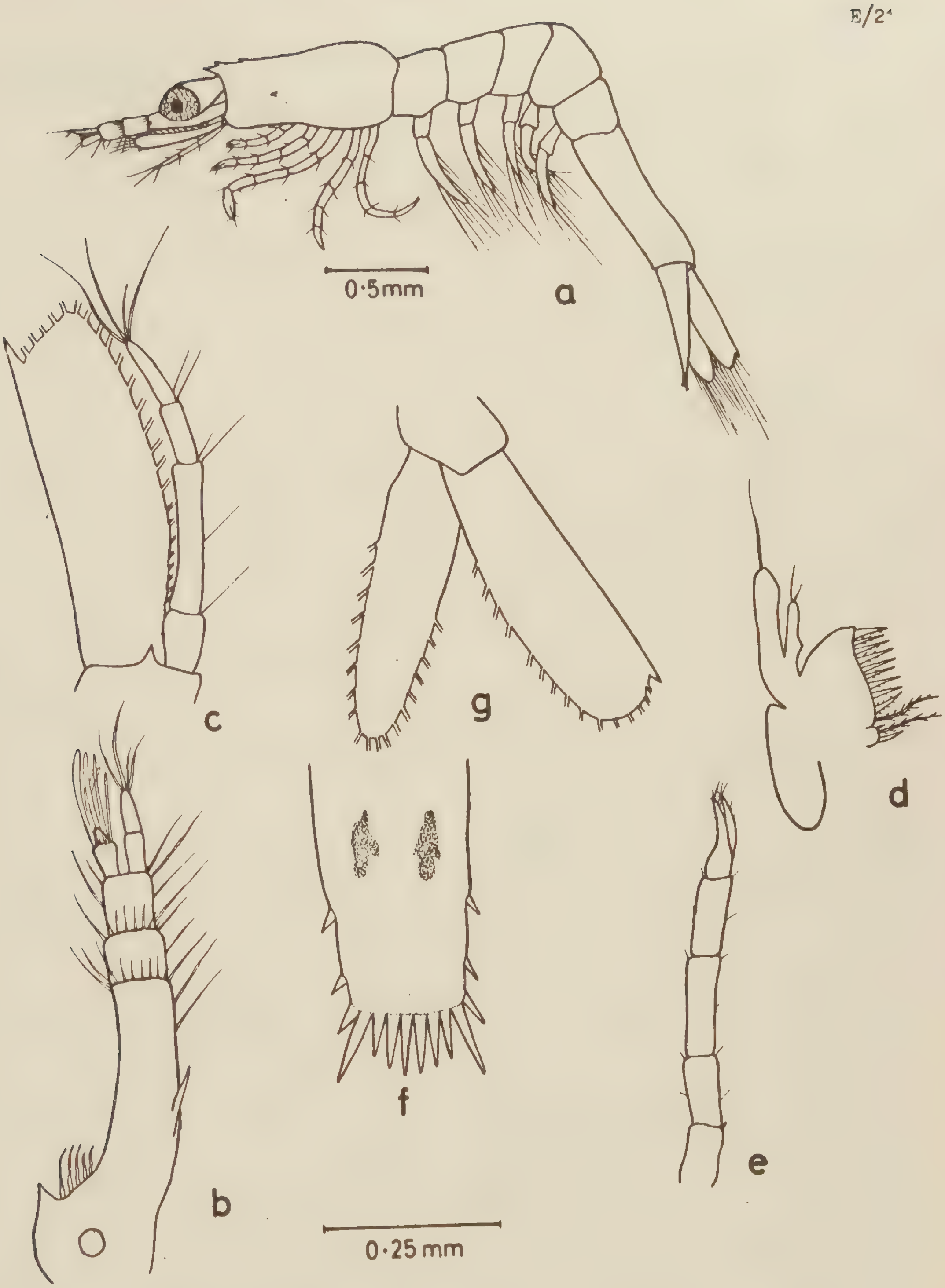

Fig. 4 Metapenaeus dobsoni, first postlarva. (a) Lateral view. (b) Antennule. (c) Antenna. (d) Maxilliped I. (e) First pereiopod. (f) Telson. (g) Uropod.

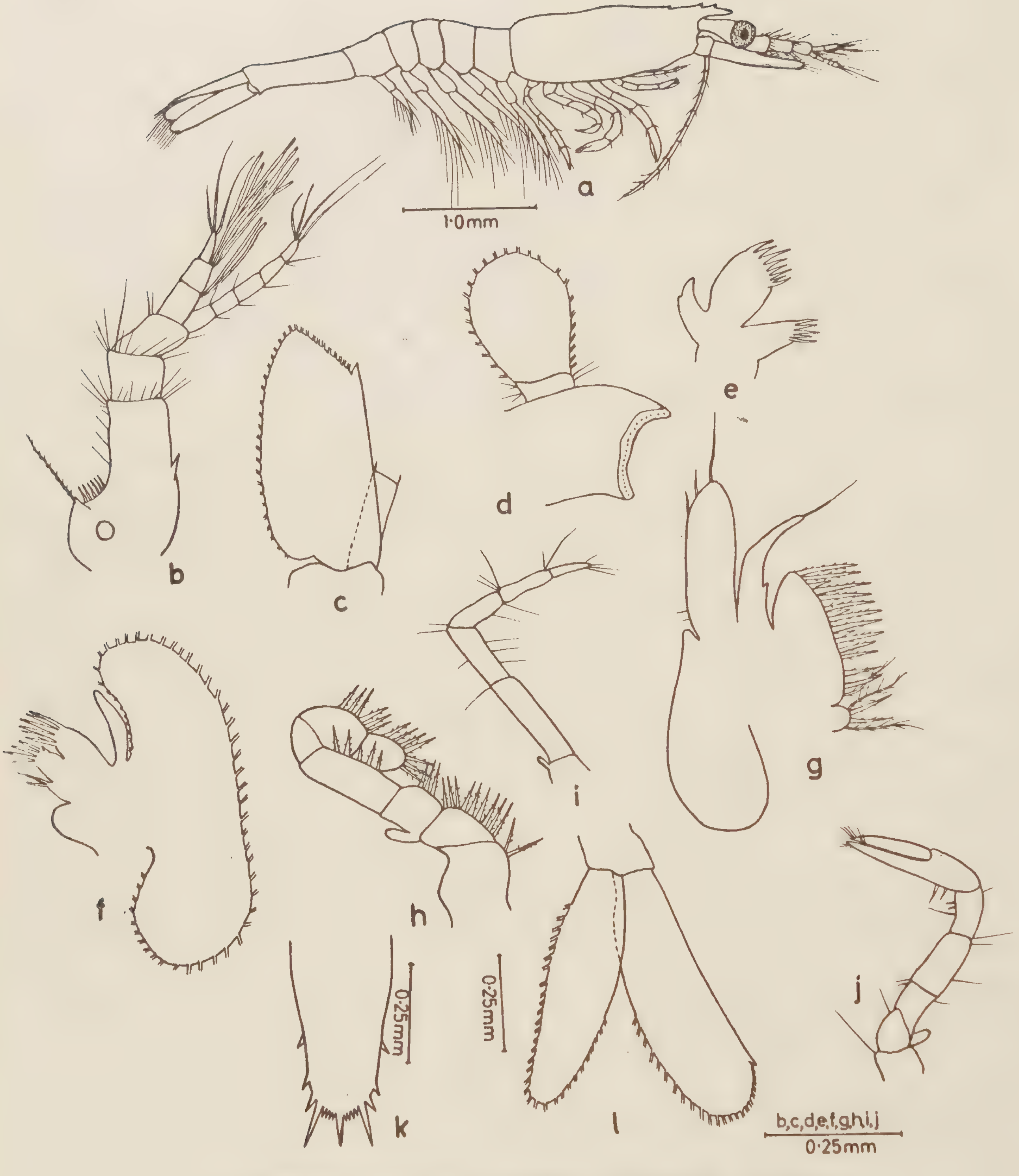

Fig. 5 *Parapenaeopsis stylifera*, first postlarva. (a) Lateral view, (b) Antennule. (c) Antenna. (d) Mandible. (e) Maxilla I. (f) Maxilla II. (g) Maxilliped I. (h) Maxilliped II. (i) Maxilliped III. (j) First pereiopod. (k) Telson. (l) Uropod.

Pleopods: Well developed and functional. All the pleopods are uniramous and 4-segmented, the distal one the smallest. The first 4 pleopods have 20 to 21 setae and the last one which is also the smallest carries only 18 setae.

Abdomen: None of the abdominal segments bear dorsal median spine, but the median ventral margin of 6th segment pointed.

Telson: With 3 pairs of lateral and 11 posterior spines. The median posterior spine is very large and almost equal in length to the large outermost pair of posterior spines. The posterior margin between the outermost pair of posterior spines tapers towards the middle spine. A few pairs of plumose setae present on the posterior margin.

Uropod: Exopod with well developed externodistal spine and 24 to 25 setae; endopod carries 32 setae.

Colouration (Fig. 6e): Tip of each segment of antennular peduncle light brownish; eye stalk yellowish. Middle region of carapace with a few branched brownish chromatophores; abdomen yellowish, the posterior portion of the last abdominal segment and the basal portion of the uropod tinged with yellowish colour and with light brownish pigment. Tip of telson light brownish.

Swimming behaviour: Swims straight forward without jerk and rests horizontally on the edges of the container.

4 COMPARISON OF LARVAE

The occurrence of postlarvae of all these species at the same time and place in the general plankton collections and their apparent similarities renders their separation to species difficult. A comparison of the various characters is given in Table I.

Comparison of some of the important features of the first postlarva of *P. indicus* with the corresponding stage of *P. kerathurus* (as *P. trisulcatus*), *P. setiferus*, *P. japonicus* and *P. duorarum*, described by Heldt (1938), Pearson (1939) and Heegaard (1953), Hudinaga (1942) and Dobkin (1961), respectively, reveals certain differences. The size of *P. indicus* larva is quite striking in that it is the largest among these. Characters, such as the presence of supraorbital spine, number of joints on the inner branch of the distal segment of the antennular peduncle, segmentation of the endopodite of first maxilla, nature of the palp of second maxilla, setation of the scaphognathite, the number of segments of exopod and endopod of first maxilliped, also show some clear differences.

The general features of the first postlarvae of *Metapenaeus monoceros*, *M. affinis* and *M. dobsoni* exhibit close resemblances, although there are clear specific features by which they could be distinguished from each other as shown in the above description. Comparison of the identical stages of *M. stebbingi*, described by Gurney (1927), and *M. bennettae* (as *M. mastersii*) (Muriel and Bennett, 1951) shows numerous common characters and a similar pattern of development. The first postlarva of *Parapenaeopsis stylifera* is clearly different from that of other species in the collection, but the general shape and nature of the telson and rostrum show apparent resemblances to that of the genus *Parapenaeus* (Heldt, 1938; Pearson, 1939; Cook, 1966).

A provisional key for distinguishing the first postlarval stages of these prawns is given below.

1	Telson with 7 + 7 spines	2
	Telson with more than 7 + 7 spines	4
2(1)	Rostrum with 4 spines (2 large and 2 small); long setae on distal lateral aspect of 6th abdominal segment	3
	Rostrum with 2 spines; no setae on distal lateral aspect of 6th abdominal segment	*Metapenaeus dobsoni*

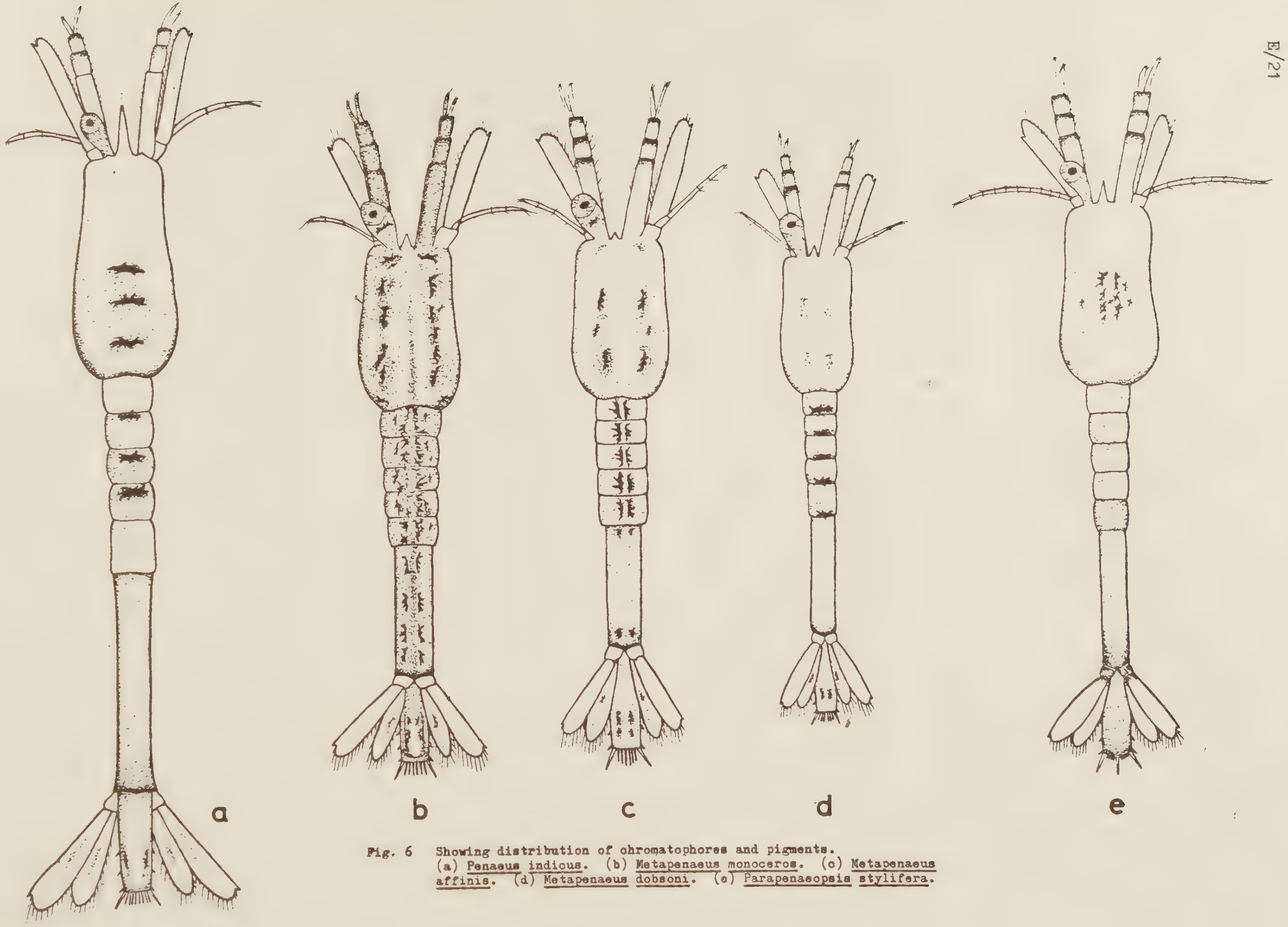

Fig. 6 Showing distribution of chromatophores and pigments.
(a) *Penaeus indicus*. (b) *Metapenaeus monoceros*. (c) *Metapenaeus affinis*. (d) *Metapenaeus dobsoni*. (e) *Parapenaeopsis stylifera*.

TABLE I

Comparison of first postlarval stages of five species

Structure	*Penaeus indicus*	*Metapenaeus monoceros*	*Metapenaeus affinis*	*Metapenaeus dobsoni*	*Parapenaeopsis stylifera*
Total length (mm)	5.22-5.95	3.75 -3.95	3.85 -3.95	3.00 -3.50	4.25 -4.75
Carapace length (mm)	1.28-1.35	1.104-1.112	1.168-1.170	0.928-0.975	1.290-1.315
Rostrum	Exceeding eye; 1 dorsal tooth	Small, not quite reaching middle of eye; 2 pairs of dorsal spines	Small; just projecting beyond frontal margin of carapace; 2 pairs of dorsal spines and 1 epigastric	Small; 2 dorsal spines	Reaching middle of eye; 2 dorsal and 1 epigastric spines
Carapace	With supraorbital and hepatic spines	With antennal and hepatic spines	With antennal and hepatic spines	With antennal and hepatic spines	With antennal, hepatic and branchiostegal spines
Antenna I	Inner branch of distal peduncular segment 3-jointed with 2 setae at tip; outer branch 2-jointed	Inner branch of distal peduncular segment 2-jointed with 4 setae; outer branch faintly segmented	Inner and outer branches of distal segment faintly jointed; inner branch with 3 setae	Inner branch of distal peduncular segment 2-jointed with 4 setae at tip; outer branch faintly segmented	Inner branch of distal peduncular segment 5-jointed with 6 setae at tip; outer branch 3-jointed
Antenna II	Flagellum 4-jointed; scale with 28 setae	Flagellum 4-5 jointed; scale with 26 setae	Flagellum 4-jointed; scale with 26 setae	Flagellum 4-jointed; scale with 24-25 setae	Flagellum 10-jointed; scale with 39 setae
Mandible	Palp jointed, distal joint with 3-4 setae	Palp jointed, distal segment with 5-6 setae	Palp jointed, distal segment with 7-8 setae	Palp jointed, distal segment with 7 setae	Palp jointed, distal segment with 25-26 setae
Maxilla I	Endopod segmented	Endopod unjointed	Endopod unjointed	Endopod segmented	Endopod unjointed
Maxilla II	4 endites; palp faintly segmented, scaphognathite with 27 setae	3 endites; palp unjointed, scaphognathite with 32 setae	3 endites; palp unjointed, scaphognathite with 39 setae	3 endites; palp unjointed, scaphognathite with 26 setae	4 endites; palp unjointed, scaphognathite with 54-55 setae
Pereiopods	1st 3 pairs without spines	1st pair with basial and ischial spines; 2nd and 3rd with basial spine only	No spines	1st 3 pairs with basial spines	No spines
Abdomen	Median dorsal spine on 5th and 6th segments	Median dorsal spine on 6th segment	Median dorsal spine on 6th segment.	Median dorsal spine on 6th segment	None of the segments with median dorsal spine
Pleopod	Uniramous, 3-jointed; distal segment with 10 setae	Same as in *P.indicus*	Same as in *P.indicus*	Same as in *P.indicus*	Uniramous, 4-segmented; distal segment with 18-21 setae
Telson	Spine formula 8 + 8; posterior margin straight	Spine formula 7 + 7; posterior margin straight	Spine formula 7 + 7; posterior margin straight	Spine formula 7 + 7; posterior margin straight	Spine formula 8 + 1 + 8; margin of telson tapering between postero-lateral spines

3(2)	Epigastric spine on the carapace present and with 1 or 2 minute spines posterior to it; distal lateral aspect of 6th abdominal segment with more than 3 pairs of setae; larva not brownish	Metapanaeus affinis
	Epigastric spine on the carapace absent; distal lateral aspect of 6th abdominal segment with 2 or 3 pairs of setae; larva appears brownish	Metapenaeus monoceros
4(1)	Telson with 8 + 8 spines; posterior margin straight median posterior spines equal; median dorsal spines present on 5th and 6th abdominal segments	Penaeus indicus
	Telson with 8 + 1 + 8 spines, posterior margin between the posterolateral spines tapering; median posterior spine very much longer than the adjacent spines; median dorsal spines on abdominal segments absent	Parapenaeopsis stylifera

5 GENERAL REMARKS

The fact that the young pelagic larvae of most of the penaeids have a strong tendency to come to shallow inshore areas or estuaries has already been established and this is true of all the species under study, except P. stylifera. This species completes its life cycle in the marine environment without entering the estuaries at any stage of its life. The rarity of its larvae in the inshore plankton and the complete absence of it in the backwater collections supports this view and suggests the possibility of their preference for offshore waters. The distribution of other species in the plankton collections reveals that the early postlarval stages of M. dobsoni are more or less equally distributed in the inshore as well as backwater plankton. In the case of M. monoceros and M. affinis, their numbers are comparatively less in the backwaters, the former species having been reported to breed in 50 to 60 m depth off Cochin (George and George, 1964). The early postlarva of P. indicus is encountered only in the collections from the offshore regions and later stages are more abundant in the backwater collections. Panikkar and Menon (1956) suggested a deeper water spawning habitat for these prawns. George (1962) observed the occurrence of large numbers of advance stage postlarva (8 to 14 mm) in Cochin backwaters. The absence of the first postlarva in the inshore plankton may probably be due to the distant location of spawning grounds, the postlarva becoming advanced stage during the period of transport to the inshore areas and backwaters. The occurrence of relatively larger numbers of advanced stage postlarvae in the backwater plankton shows that they are no longer passive and that they have by this time developed sufficient locomotory powers to withstand the flow of ebb tide.

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SOME ASPECTS OF THE BIOLOGY OF WHITE SHRIMP *Penaeus schmitti* BURKENROAD, IN LAKE UNARE, VENEZUELA

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Abstract

This study shows that shrimp larvae of *Penaeus schmitti* enter Lake Unare in July at an average size of 8.5 mm. By October they grow to an average size of 90 mm and enter the commercial catch. Fishing is done in the lake from October to May. The sex ratio is almost 1:1 but the female attains a larger size than the male. Carapace lengh-total length relationship is almost linear. Length-weight relationship is illustrated. Ecology of the lake is also discussed.

QUELQUES ASPECTS DE LA BIOLOGIE DE LA CREVETTE *Penaeus schmitti* BURKENROAD DANS LE LAC UNARE, VENEZUELA

Résumé

L'étude indique que les larves de *Penaeus schmitti* pénètrent dans le lac Unare en juillet à la taille moyenne de 8,5 mm. En octobre, les animaux mesurent en moyenne 90 mm et entrent dans la phase exploitée par la pêche commerciale. La pêche est pratiquée dans le lac d'octobre à mai. Le sex-ratio se rapproche de 1/1, la femelle atteignant une taille supérieure à celle du mâle. Le rapport longueur de carapace/longueur totale est pratiquement linéaire. La communication illustre le rapport longueur/poids, et traite également de l'écologie du lac.

ALGUNOS ASPECTOS DE LA BIOLOGIA DEL CAMARON BLANCO *Penaeus schmitti* BURKENROAD EN EL LAGO UNARE, VENEZUELA

Extracto

Según este estudio, las larvas de *Penaeus schmitti* entran en el lago Unare en julio con un tamaño medio de 8,5 mm. En el mes de octubre este tamaño aumenta a 90 mm, y ya forman parte de la captura comercial. En el lago se pesca de octubre a mayo. La relación de sexos es de casi 1:1, pero la hembra alcanza mayor talla que el macho. La relación longitud total - longitud del caparazón, es casi lineal. Se expone la relación longitud-peso y se estudia también la ecología del lago.

1 INTRODUCTION

The white shrimp, Penaeus schmitti is found in Cuba, Jamaica, Haiti, the Dominican Republic, Panama, Colombia, Venezuela, the Guianas and Brazil (Boschi, 1963).

P. schmitti is abundant in the shallow waters all along the coast of Venezuela. At present it is the principal species caught in Lake Maracaibo and Lake Unare. This species is also found in the eastern region, in the Gulf of Paria, but the fishery there is not yet well developed (Khandker, 1965). In Lake Maracaibo this species is considerably mixed with other Penaeus spp (Ewald, 1965), but in Lake Unare it is the most predominant one. P. schmitti is also predominant in Lake Piritu, which is adjacent to Lake Unare (Fig. 1).

In 1963 the total shrimp catch from Lake Unare was 48,640 kg. This is of course very insignificant when compared with the catch of 3,842,650 kg from Lake Maracaibo in the same year. However, it has to be borne in mind that the offshore waters near Lake Unare are yet unexploited. Weibezahn (1952) reported that there were possibilities of good catch from that area but that detailed charting of the grounds was necessary before starting commercial fishing.

In Lake Unare fishing for shrimp is carried out from October to May, the maximum catch is normally in January or February. About 200 fishermen do the fishing using cast nets of 2 cm mesh size either from shore or dugout canoes of about 4 m in length. The catch is sold fresh to various fishing companies who send their trucks with ice to collect shrimp.

2 OBSERVATIONS

2.1 Ecology of the Lake Unare

During the rainy season from June to August the lake attains the maximum area of 64 km^2 and a depth of 1.5 m. In the dry season the level of water drops down by about 0.8 m, reducing the area by 34 percent. The salinity of the lake varies very much in the different seasons. In 1963 the lowest salinity recorded was 19.32 $^o/_{oo}$ in July, and the highest was 77.95 $^o/_{oo}$ in April. The temperature varied only slightly, the maximum was 30.6°C in September and the minimum 28.2°C in March.

During the rainy season, fresh water enters the lake through three rivers of which the River Unare is the most important (Fig. 1). The river opens into the sea in between Lake Unare and Lake Piritu. The River Unare is connected with the Lake Unare by two canals, and the lake is connected with the sea only through the river. The mouth of the river at the sea is only open for 6 months from July to December, being closed by silt during the other months.

The animal communities of the lake consist of 34 species of fish and various invertebrates. The most abundant and commercially important fishes are: mullets, Mugil liza and M. curema, mojarras of the genera Diapterus, Eugerres and Eucinostomus and catfishes of the genera Arius and Selenaspis. The invertebrates are mainly crabs of several species, gastropods of the genera Albania and Bittum, bivalves of the genus Tagelus and some oligochaetes.

2.2 Early life history

Plankton samples taken from the sea shore near the lake, in June and July, showed the presence of shrimp postlarvae. Postlarvae began to enter the lake through the River Unare in July. The average size of the postlarvae entering the lake was 8.5 mm. No work has yet been done on the early life history of P. schmitti so larval stages could not be identified definitely. They resembled very closely the larval stages of P. setiferus as described by Pearson (1939). After entering the lake, postlarvae settle down on the bottom and are not found in the plankton samples. The postlarvae

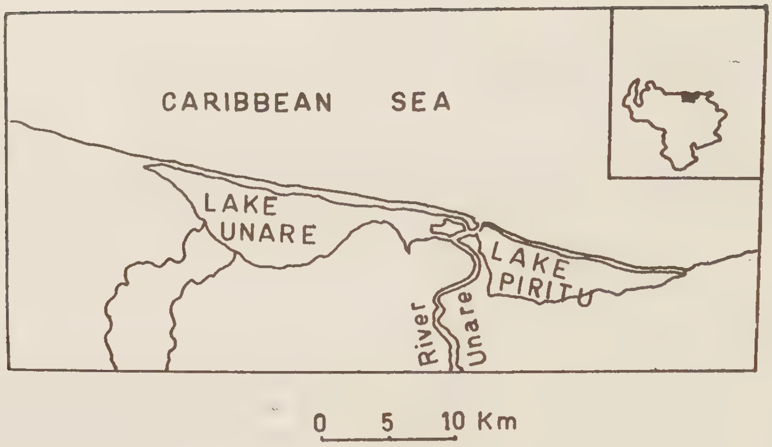


Fig. 1 Map of Lake Unare.

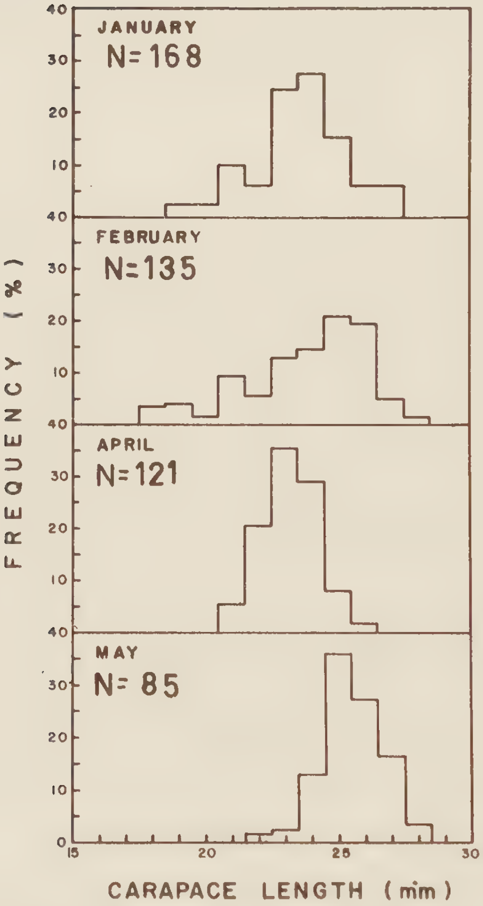


Fig. 2 Length-frequency distribution of Penaeus schmitti in Lake Unare during 1964.

grow rapidly and by October attain an average size of 90 mm growing almost 1 mm per day. This rate of growth coincides with that of P. setiferus as reported by Lindner and Anderson (1954).

2.3 Size and weight of adults

Samples of shrimp were collected mainly from fishermen but occasionally some sampling was done with a beam trawl having a mesh of 20 mm. Shrimps were measured and weighed fresh. Total length measured was from the tip of the rostrum to the end of the telson, and carapace length from the orbital notch to the posterior mid-dorsal edge of the cephalothorax.

The length-frequency distribution of shrimps collected and examined between January and May 1964 is given in Fig. 2. A decrease in average size was observed in April compared with that in January and February. In May a shifting of the modal size by 2 mm carapace length was indicated, which corresponds to a growth of about 8 mm in total length. Lindner and Anderson (1954) indicated that in P. setiferus the growth is rapid till October, after which it remains almost stationary until the end of February or March. It appears that in Lake Unare, P. schmitti also grows rapidly till October, after which it slows down.

The relationship between carapace length and total length in male and female P. schmitti is shown separately in Fig. 3. No significant difference is observed between the two sexes. Although there is large variation in the total length for a certain carapace length, the relationship is almost linear. Such linear relationship was also observed in P. duorarum by Iversen and Idyll (1960).

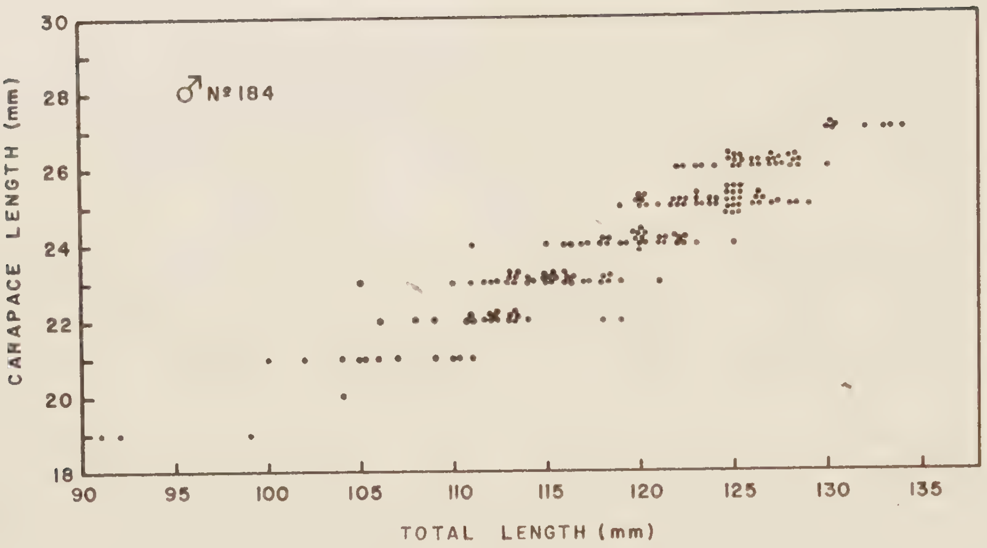
There is a slight size disparity between the two sexes, the female attaining a bigger size. This size disparity is common in other penaeids, as reported by Weymouth Lindner and Anderson (1933) and Iversen and Idyll (1960).

The length-weight relationship of male and female P. schmitti is shown in Fig. 4. No significant difference is observed between the two sexes. In Table I the relationship between carapace length, total length and weight has been summarized combining both sexes.

TABLE I

Length-weight relationship of Penaeus schmitti with both sexes combined

Carapace length (mm)	Total length (mm)	Weight (g)
18	89	5.7
19	96	6.8
20	104	8.8
21	106	9.5
22	112	10.7
23	116	11.8
24	119	13.0
25	123	14.4
26	126	15.5
27	131	17.2
28	134	18.6



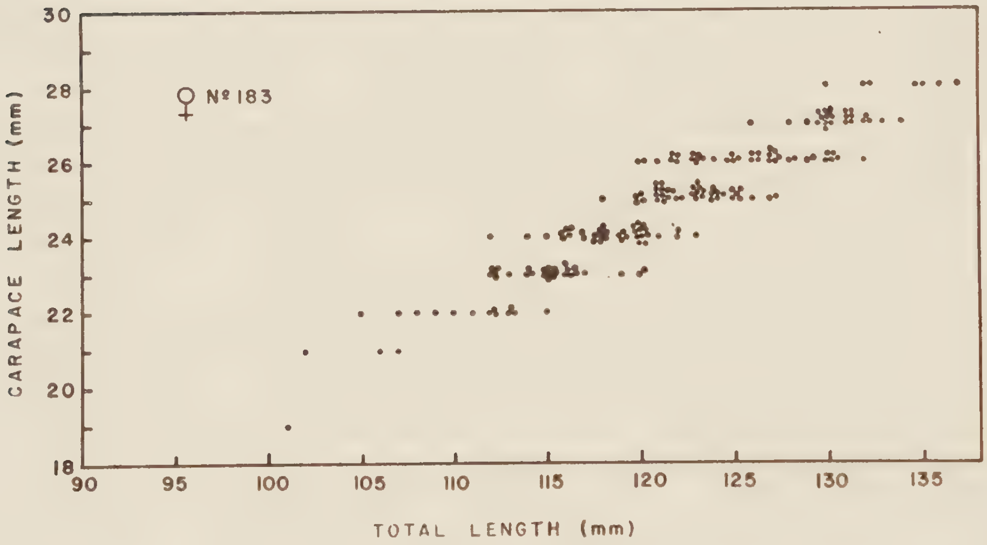


Fig. 3 Relationship of carapace length to total length in males and females of Penaeus schmitti.

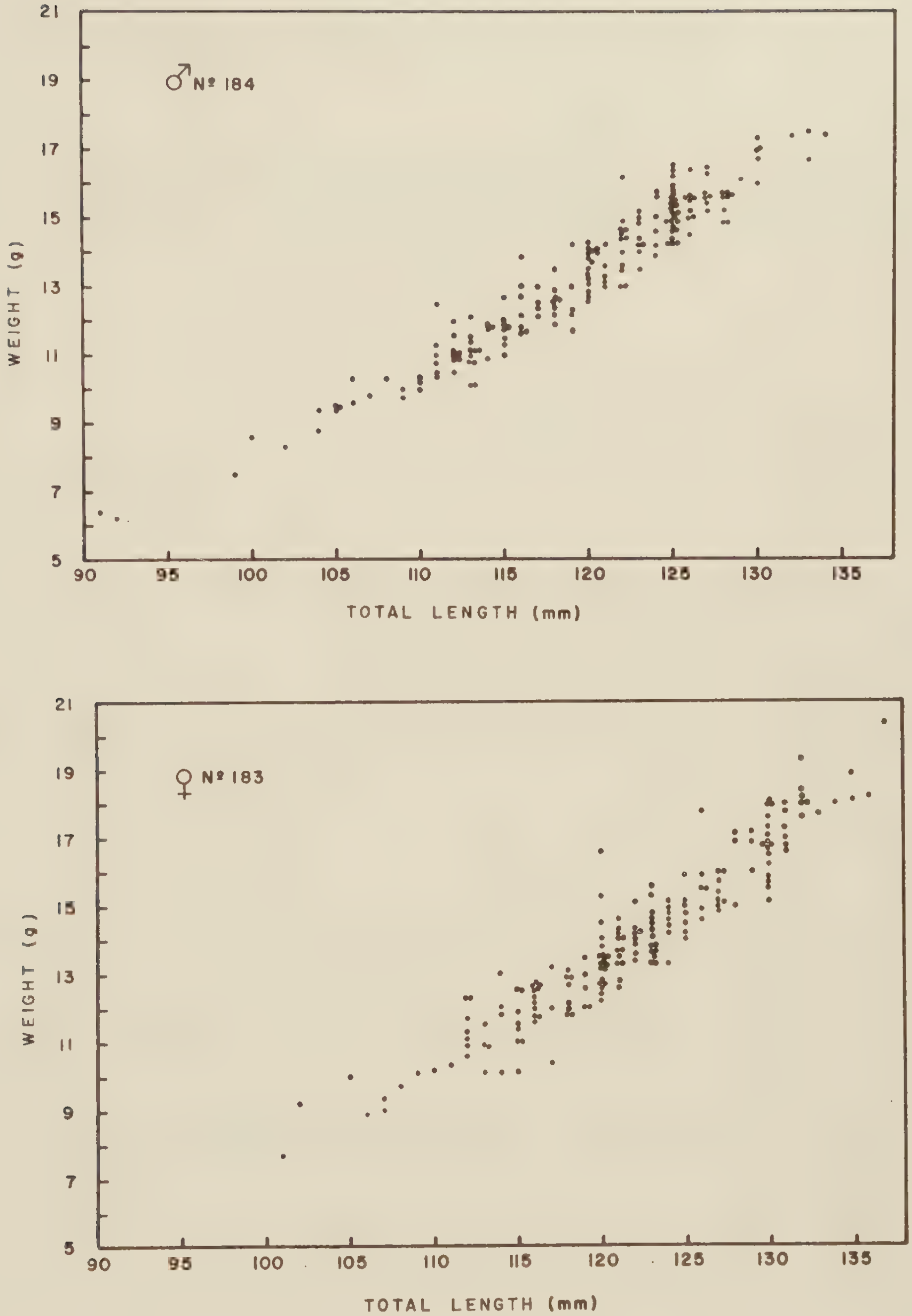


Fig. 4 Length-weight relationship in males and females of Penaeus schmitti .

2.4 Sex ratio

Sex ratio was found to be almost 1:1. Although there is a size disparity it probably did not affect the ratio because above the length of 90 mm both sexes are equally retained in the net.

2.5 Maturation and spawning

The maximum size female obtained was 137 mm and at that length the ovary would be naturally underdeveloped, as shown in *P. setiferus* by King (1948). All ovaries examined in fresh condition and histological sections, were immature. Plankton samples taken in River Unare and Lake Unare in May and June did not show presence of larvae of *P. schmitti*.

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THE DESIGN AND FIELD TESTING OF AN ELECTRO-SHRIMP TRAWLING SYSTEM

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Abstract

The Gear Research Unit of the Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi, has been developing an electrical shrimp trawl since 1961. A battery-powered model, completed in 1964, was found to be inadequate. A re-examination was then made in the eastern Gulf of Mexico of shrimp's responses to various electrical fields. It was observed that shrimp responded most rapidly when burrowed in a mud substrate and the minimum electrical field was found to be 3.0 V at 4 to 5 pulses/sec. With these data, the staff designed and built a new prototype electro-shrimp trawl system. The system, when operating, receives, from the vessel's generator, alternating current (AC) which is transmitted by an electrical cable to an electronic pulse generator on the trawl door, where it is converted to direct current (DC) and is then released at a specified pulse rate to an electrode array on the trawl. Fishing trials on the north Gulf shrimp grounds indicated the system could catch, during daylight, 96 to 109 percent of the shrimp caught at night by a conventional trawl. In the southeastern Gulf the catch dropped about 50 percent. Two possible reasons suggested for the smaller catch are: 1) a reduction of the electrical field because of a change in substrate from mud to a sand-shell composition and 2) also the possibility that shrimp burrow deeper in a sand-shell substrate.

E/23

REALISATION ET ESSAI EN MER D'UN DISPOSITIF DE CHALUTAGE ELECTRIQUE DE LA CREVETTE

Résumé

Le Service de recherche sur les engins de pêche de la Base de pêche exploratrice et de recherche sur les engins de Pascagoula (Mississippi) travaille depuis 1961 à la mise au point d'un chalut à crevettes électrifié. Un modèle à accumulateurs, achevé en 1964, n'a pas donné de bons résultats. On a alors procédé, dans la partie est du golfe du Mexique, à de nouvelles études des réactions des crevettes à divers champs électriques. La réaction la plus rapide a été observée lorsque les animaux étaient enfouis dans un substrat vaseux et pour un champ électrique minimal de 3,0 volts à 4-5 impulsions par seconde. Sur la base de ces données à été conçu et construit un nouveau prototype de chalut à crevettes électrifié. Le dispositif fonctionne de la façon suivante: le générateur du bord envoie un courant alternatif, qu'un câble électrique transmet à un générateur d'impulsions électronique installé sur le panneau de chalut, où il est converti en courant continu, envoyé avec une certaine fréquence d'impulsion à une série d'électrodes placées sur le filet. Sur la base d'essais de pêche effectués sur les fonds à crevettes de la partie nord du golfe, l'engin pourrait capturer, en plein jour, de 96 à 109% des quantités de crevettes pêchées la nuit au chalut de type classique. Dans le secteur sud-est du golfe, les prises ont diminué d'environ 50%. Deux explications sont suggérées: 1° diminution du champ électrique due à la difference de substrat, le fond n'étant plus vaseux, mais sablo-coquillier; 2° possibilité que les crevettes s'enfouissent plus profondément dans un tel substrat.

PROYECTO Y ENSAYO PRACTICO DE UN SISTEMA ELECTRICO DE PESCA AL ARRASTRE DEL CAMARON

Extracto

El Grupo de Investigaciones de Equipo de la Base de Investigaciones de Equipo y Pesca Exploratoria de Pascagoula, Mississippi, estudia desde 1961 un arte de arrastre eléctrico para la pesca del camarón. En 1964 se terminó un modelo accionado por baterías que no dio resultados. Posteriormente, en la parte oriental del Golfo de México se estudiaron de nuevo las reacciones del camarón a diversos campos eléctricos, observándose que reaccionaba más rápidamente cuando estaba enterrado en un substrato de fango, y que el campo eléctrico mínimo era de 3,0 V a 4 ó 5 impulsos por segundo. Con estos datos, el personal proyectó y construyó un nuevo prototipo de sistema eléctrico de arte de arrastre camaronero. Cuando está en funcionamiento, el sistema recibe del generador de la embarcación una corriente alterna que se transmite por un cable eléctrico a un generador de impulsos electrónico en la puerta del arte, en el que se transforma en corriente continua y que, a una velocidad de impulso especificada, se descarga a un conjunto de electrodos en el arte. Los ensayos de pesca en los bancos de camarones del norte del Golfo indican que durante el día, el sistema puede capturar el equivalente del 96 al 109 por ciento del camarón que se pesca de noche con un arte ordinario. En la parte sudoriental del Golfo, la captura se redujo a cerca del 50 por ciento. Dos razones que posiblemente explican esta disminución son: (1) una reducción del campo eléctrico debido a que el substrato era de arena y conchas en lugar de fango; (2) la posibilidad de que el camarón se entierre más profundamente en un substrato de arena y conchas.

1 INTRODUCTION

Preliminary studies to determine the possibility of developing an electrical system for catching shrimp began in 1961 at the Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi. The objectives were to provide a system which would give the commercial shrimp fleet the capability of working continuously on a 24-hour basis rather than the 12 hours per day the vessels currently work. This is because during daylight most shrimp burrow in the bottom, whereas at night they come out to forage for food. Therefore, commercial fishing for nocturnal species of shrimp is restricted to night trawling. It was theorized that a more effective use of manpower and equipment would be realized and production costs could be reduced proportionately if the shrimp could be caught during their inactive period. Two phases of the early work were presented to the Second World Fishing Gear Congress in 1963. Fuss (1964) reported on the burrowing behaviour of pink shrimp, *Penaeus duorarum* Burkenroad and Wathne (1964) reported on their response to low voltage electricity. Following this work, experiments were conducted to determine the components for a working electrical trawl model. Electrical parameters were determined but staff limitations at that time did not permit in-house designing or fabricating the necessary electronic components, therefore bids were requested from several industrial electronic companies (Wathne and Holt, 1964). The electronic unit provided by the selected company in 1964 was a compact, battery-powered pulse generator that was designed to be attached to a trawl door. This unit produced an electrical field of about 0.5 V at 2 pulses/sec. Fishing trials were encouraging from the operational aspect but catch results were considered poor by commercial shrimp fleet standards. The electrical field was not adequate to force shrimp out of the bottom. Therefore it became necessary to examine closely shrimp's responses to various electrical fields.

2 SHRIMP BEHAVIOURAL EXPERIMENTS

A project was initiated to determine the optimum electrical requirements necessary to electrically stimulate shrimp burrowed in the substrate (Klima, MS). Because of the difficulty in obtaining accurate *in situ* measurements, underwater motion picture photography was selected to document these responses. During the first phase, laboratory studies determined the threshold voltages of shrimp placed at various angles to the electrodes. In the second phase, the escape reaction of burrowed shrimp from different type substrates was recorded for various combinations of voltages and pulse rates. Over 1,000 shrimp were individually stimulated and photographed on 16 mm motion picture color film by SCUBA divers in the eastern Gulf of Mexico. The minimum power requirements necessary to force shrimp out of the substrate were determined by analyzing these films. These requirements were 3.0 V at 4 to 5 pulses/sec.

3 SYSTEM DESIGN

The Gear Research Unit staff designed and fabricated a prototype electro-shrimp trawl system that produces an electrical field immediately in front of a shrimp trawl. The electrical field causes an involuntary "kicking" response in shrimp that forces them out of the substrate and into the path of the oncoming trawl. The system has four primary components: 1) the power control panel aboard the vessel, 2) a power cable from the vessel to a trawl door, 3) an electronic pulse generator mounted on one of the trawl doors, and 4) an electrode array.

3.1 Electrical Power Panel

The power panel consists of a variable transformer, two voltameters, two lights, and an on-off switch. The vessel's generator furnishes 110 V AC to the panel. Voltage from the panel to the pulse generator is controlled with a variable transformer and is monitored on one of the voltameters. The second voltameter shows the voltage output of the pulse generator. One light indicates when the power is on between the panel and the pulse generator and the other light flashes synchronously with the pulse rate output of the pulse generator.

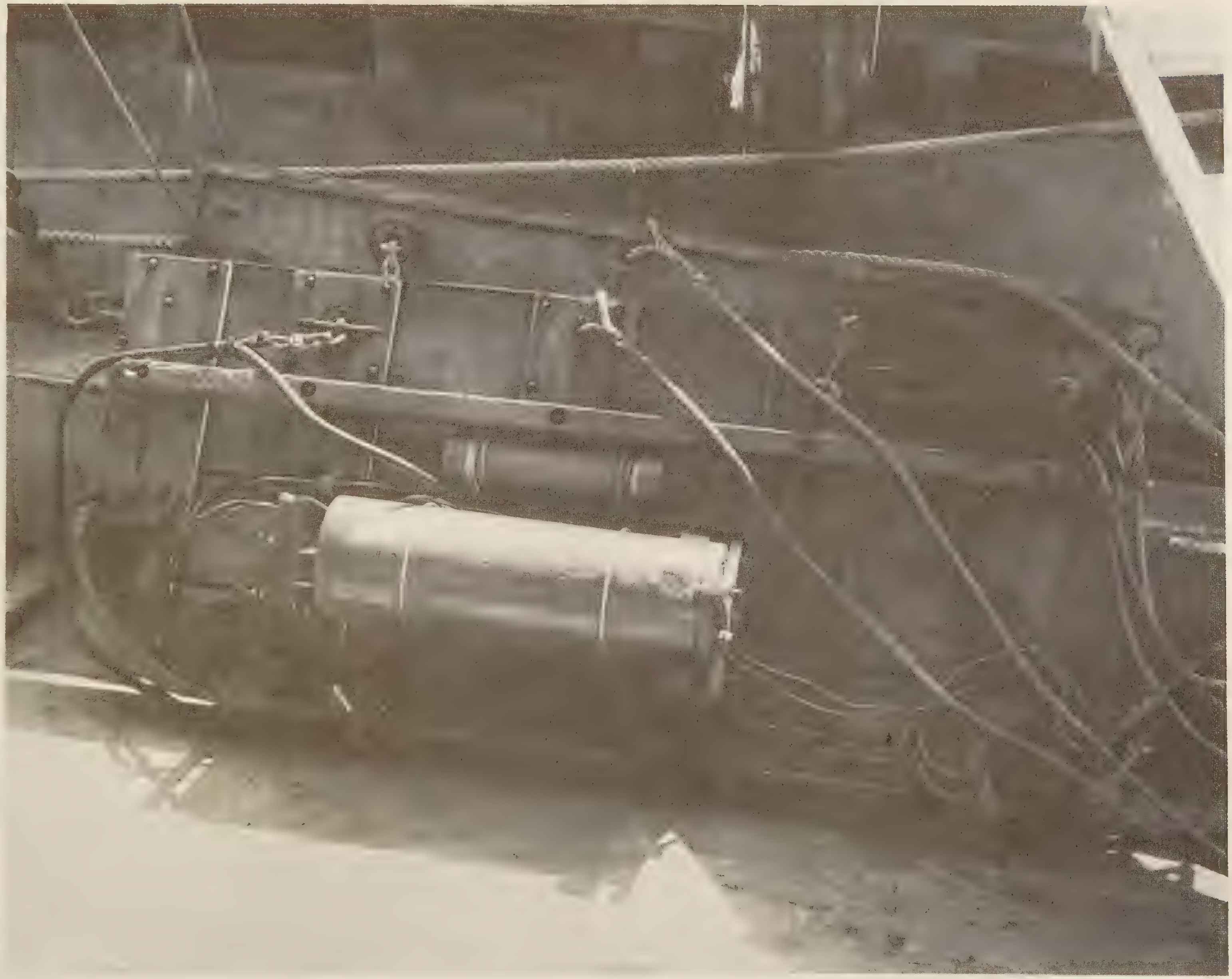

Fig. 1 The polyvinyl chloride housing for the electronic pulse generator is shown mounted on a trawl door. The small galvanized pipe housing immediately above contains a 225-W resistor which was located separately to dissipate the heat it created.

3.2 Electrical Power Cable

A 4-conductor, American wire gauge No. 12, neoprene covered cable about 300 m long was used during the testing of the system. Two of the conductors were to supply the AC to the pulse generator and the other two monitored the pulse rate from the pulse generator. This cable provided ample power to the system.

3.3 Electronic Pulse Generator

The pulse generator converts a.c. received from the vessel to DC. It stores the electricity in a bank of capacitors and releases the DC to the electrodes at a predetermined pulse rate. The electronic components are mounted on a Bakelite[1] board and are encased in a cylindrical watertight polyvinyl chloride (PVC) housing 20.3 cm nominal diameter (Fig. 1). The electrical power connections in and out of the housing are made with watertight connectors.

During initial field trials of the electrical components, heat generated within the housing did not disseminate into the surrounding water and caused premature failure of several components. The insulating qualities of the PVC apparently caused the excessive heat build-up. Two approaches to eliminate this problem were considered. The first was to design and build a new housing from material which would conduct the internal heat to the water. The second approach was to remove from the PVC housing the major heat creating source, a 225 W resistor, and place it in a separate galvanized iron pipe housing. In the interests of expediency, the second approach was adopted. In addition, cooling oil was used inside the PVC housing to help dissipate the heat. The resistor was housed separately and was then wired to the adjacent pulse generator. The unit functioned satisfactorily after the change was made.

3.4 Electrode Wires

Five electrode wires the width of the trawl opening were secured so that they would hang in even bights about 61.0 cm apart, parallel to and ahead of the trawl footrope (Fig. 2). The last one was placed immediately ahead of the trawl footrope. The current from the pulse generator was released directly to each electrode to create the electrical field. Experiments were conducted with several kinds of wire. The problem was to find a wire that could withstand the rigors of being dragged over the bottom and carry an electrical current. The last wire which we tried had 6 strands, 3 strands of insulated stainless steel wire for strength and 3 strands of exposed copper wire to carry the current. This wire performed satisfactorily during our field trials.

4 FIELD TRIALS

The final phase of the project was to determine the ability of the system to catch burrowed shrimp during daylight from various commercial shrimp grounds in the Gulf of Mexico. In the northern Gulf the major producing areas are located intermittently from northwest Florida to Texas where the predominant commercial species of nocturnal shrimp is the brown shrimp, Penaeus aztecus Ives. In the shrimp grounds off south Florida, the pink shrimp, P. duorarum, replaces the brown shrimp in this ecological niche.

Two locations in the northern Gulf and one in the south Florida grounds were selected for the fishing trials. The first of these areas ran confluently along the Alabama and Mississippi Continental Shelf. Several river systems flow into large bay areas providing favorable inshore conditions for shrimp nursery grounds. Offshore, in the 9 to 27 m depth range, the obstruction-free substrate is a soft black mud. It was in the latter area that the fishing trials were held. The second area was the coastal shelf off Freeport, Texas, where environmental conditions are similar to those found in the Alabama-Mississippi area, however the shelf is broader and provides more dragging area. On the Tortugas shrimp grounds in southern Florida, the substrate is a calcareous, sand-shell composition. Species of gastropods, echinoderms, and sponges, which are found here, are sometimes collected in the net and create problems while dragging. Approximately 130 km to the north of the Tortugas are the Sanibel shrimp

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[1] Trade names referred to in this publication do not imply endorsement of commercial products

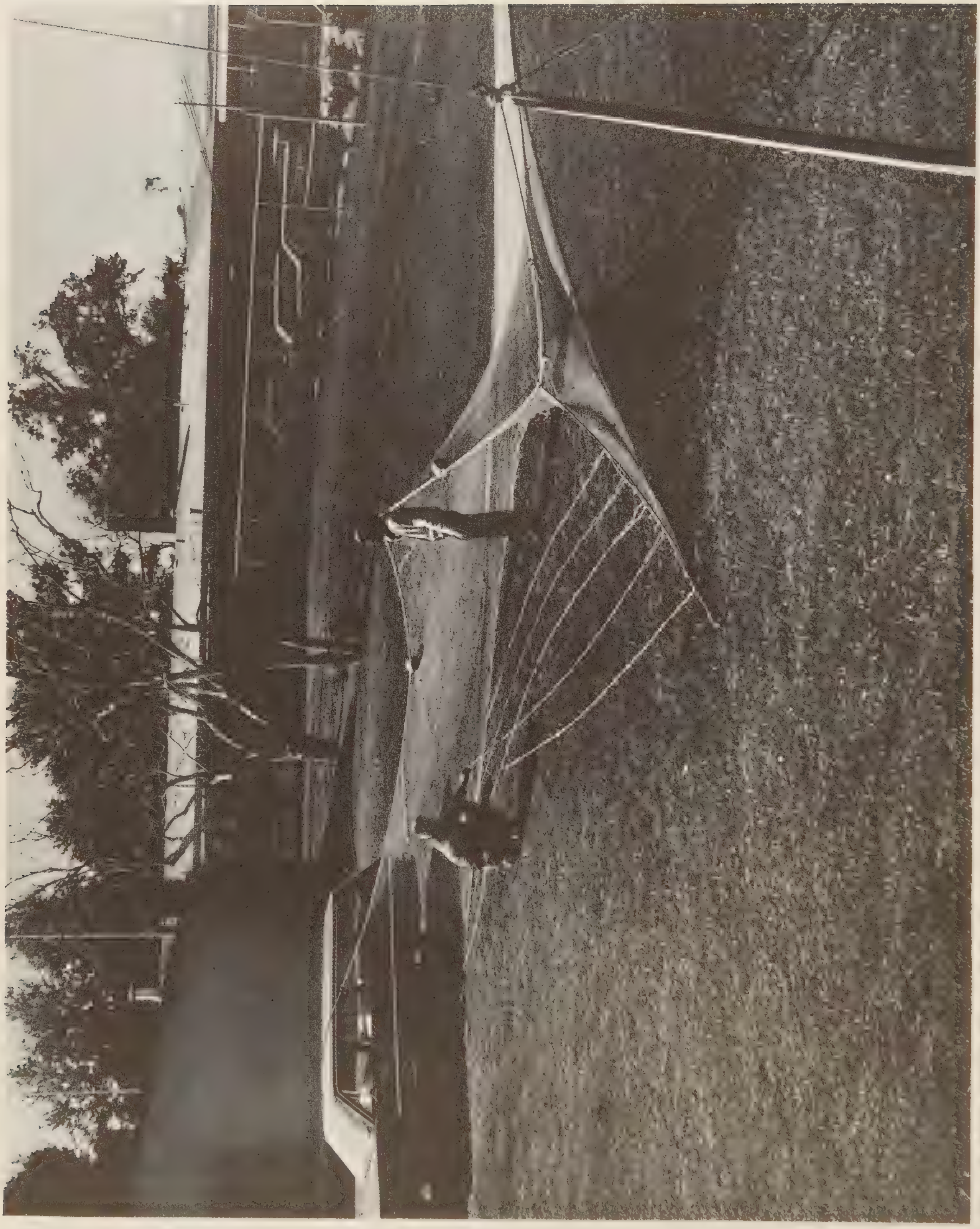

Fig. 2 A shrimp trawl stretched open showing configuration of electrode array in front of trawl footrope.

grounds where brief trials were held. The bottom there is composed of broken shell with small corals and the pen shell, Atrina rigida, thriving profusely. These conditions prevented us from making any significant catches.

4.1 Methods

The United States Bureau of Commercial Fisheries research vessel GEORGE M. BOWERS was used for the experimental fishing. It is a 22.6 m (LOA) wood-hull shrimp vessel, which is rigged for double trawling with two 8.0 m outrigger booms. A two-drum trawling winch, which is powered by a mechanical power take-off from the main engine, holds 734 m of trawl wire. Standard 12.2 m flat Gulf of Mexico shrimp trawls (Bullis, 1951) constructed of 5.1 cm stretched-mesh nylon with polydacron hanging lines were used. One of the trawls was rigged with a single tickler chain, which was secured to a bracket on the lower rear of each of the 2.1 m trawl doors. The other trawl had the electro-shrimp trawl components.

To test the effectiveness of the electric trawl, both trawls were dragged simultaneously day and night so we could make comparisons of the individual trawl catch rates. The significant figures were the comparison of the nighttime catches with the non-electric trawl and the daytime catches with the electric trawl. Upon reaching the strimp grounds, a series of night drags would be completed in a given area and the catch results recorded. Then, during daylight, another series of drags would be completed in the same area. This procedure was repeated during the entire cruise. By comparing the results, it was possible to assess the fishing ability of the electric trawl. All drags discussed here were 1 h long.

4.2 Results

During fishing trials to test the system, 134 double-rigged drags were completed. These were divided among the three fishing locations. In the two northern Gulf areas, daytime average catches with the electric trawl were 8.1 kg/h and 7.0 kg/h (Table I). Nighttime average catches with the non-electric trawl were 7.4 kg/h and 7.3 kg/h, respectively. A comparison of these averages shows that during the day the electric trawl caught 109 percent and 96 percent of the night non-electric trawl catch. On the Tortugas shrimp grounds the daytime average catch with the electric trawl was 8.6 kg/h and the nighttime average catch with the non-electric trawl was 17.0 kg/h, a ratio of 50.1 percent.

The electric trawl catch in all areas fished at night was consistently less than the non-electric night trawl catch. The reason for this was not determined.

TABLE I

Average shrimp catches from comparative fishing trials made with electric and non-electric shrimp trawls

		Alabama-Mississippi		Texas		Florida (Tortugas)	
		Electro-trawl	Non-elect. trawl	Electro-trawl	Non-elect. trawl	Electro-trawl	Non-elect. trawl
DAY	No of drags	19	19	18	18	29	29
	kg/h	8.1	3.3	7.0	0.3	8.6	0.4
NIGHT	No of drags	10	10	20	20	23	23
	kg/h	5.9	7.4	4.5	7.3	12.0	17.0

5 DISCUSSION

Tests with this equipment on commercial shrimp grounds demonstrated that the system will catch commercial quantities of shrimp during the day when they are not available to conventional gear. We did not experience any unusual or awkward gear handling problems. The electrodes did not become entangled, and the pulse generator housing was neutrally buoyant and did not appreciably affect the trawl door to which it was attached. The electric cable, which was handled separately, could be improved for industry application. For example, an armored electric cable, which could also serve as a trawl warp, would eliminate the extra handling now necessary.

The fishing results demonstrated that the electrical system was capable of increasing a vessel's shrimp catch. The ratio of day to night catches is apparently related to the type of substrate in the area being fished, the latter probably is related to the ability of electricity to penetrate the different substrate compositions. During behavior studies, shrimp emerged faster and jumped higher from mud than from any other type of substrate. During fishing trials the highest catch ratio was made from a mud substrate. When gear trials were moved to the Tortugas area, the catch ratio, as noted earlier, dropped almost 50 percent. The difference in substrate, from mud in the northern grounds and a sand-shell in the southeastern grounds, is believed partly responsible because the sand-shell substrate retarded the penetration of the electrical field. Williams (1958) reported that pink shrimp, P. duorarum, burrow deepest in a sand-shell substrate. On the Sanibel shrimp grounds, the substrate was entirely of broken shell. This created severe conditions for the electrical field and contributed to the low catch in this area. Additional research should be conducted to study the relation between a sand-shell substrate and an electrical field. From the information gathered during this project, it is suggested that manufacturing and distribution of this system by private enterprise will be beneficial to the fishing industry.

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THE SHRIMP FISHERY OF BRITISH COLUMBIA

by

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Abstract

Shrimp fishing in British Columbia is a minor operation, with total landings of 764.5 metric tons, valued at $300,000 in 1966. Six species of the genera Pandalus and Pandalopsis are generally recognized by fishermen. Main gear is the beam trawl, but there are also baited traps which are fished for species on rocky bottom. Commercial fishing has been carried on for over 75 years, and evidently began near Victoria. Between the world wars, production mainly from the Vancouver area was dominated by Pandalus danae and remained below 110 tons. A post-war expansion was supported by P. borealis and after 1952, yields of P. jordani from Vancouver Island grounds have kept production at a level exceeding 450 tons. In 1954 several productive areas were found by the Fisheries Research Board of Canada. The assumption is that certain stocks are now being trawled rather intensely. Prospects for future expansion are good.

LES PECHERIES DE CREVETTES DE LA COLOMBIE BRITANNIQUE

Résumé

En Colombie britannique, la pêche de la crevette n'a qu'une importance secondaire, les apports totaux s'étant montés en 1966 à 764,5 tonnes, pour une valeur de 300 000 dollars. Les pêcheurs identifient généralement six espèces, appartenant aux genres Pandalus et Pandalopsis. Elles se pêchent surtout au chalut à perche, mais l'on utilise aussi des pièges appâtés pour capturer les espèces des fonds rocheux. La pêche commerciale s'exerce depuis plus de 75 ans, et a manifestement débuté aux environs de Victoria. Entre les deux guerres mondiales, la production (surtout dans la zone de Vancouver) était dominée par Pandalus danae, et n'atteignait pas 110 tonnes. Après la Seconde Guerre mondiale, la pêche a connu une expansion alimentée par P. borealis, et depuis 1952 la production se maintient au-dessus de 450 tonnes grâce à l'exploitation des P. jordani des bancs de l'île Vancouver. En 1954, l'Office technique et scientifique des pêches canadien a découvert plusieurs zones productives. On suppose que certains stocks font actuellement l'objet d'un chalutage assez intense. Les perspectives d'expansion sont bonnes.

LA PESCA DEL CAMARON EN LA COLUMBIA BRITANICA

Extracto

La pesca del camarón en la Columbia Británica es de pequeña escala: en 1966 se capturaron 764,5 toneladas métricas en total, valoradas en 300.000 dólares. Los pescadores suelen reconocer seis especies de los géneros Pandalus y Pandalopsis. El equipo principal son los artes de vara, pero también se emplean nasas cebadas para pescar especies de los fondos rocosos. La pesca comercial se viene practicando desde hace más de 75 años y evidentemente empezó cerca de Victoria. Durante el período comprendido entre las dos guerras mundiales, la producción, que procedía principalmente de la zona de Vancouver, estaba dominada por Pandalus danae y no llegó a superar las 110 toneladas. Después de la guerra se produjo un aumento, atribuible a P. borealis, y desde 1952, los rendimientos de P. jordani de los caladeros de Vancouver Island han mantenido la producción a un nivel superior a las 450 toneladas. En 1954, la Junta de Investigaciones Pesqueras del Canadá encontró varias zonas productivas. La impresión es que ciertas poblaciones se están pescando al arrastre actualmente, con bastante intensidad. Las perspectivas de expansión en lo futuro son buenas.

1 INTRODUCTION

The shrimp fishery is a minor yet thriving fishing operation in British Columbian waters. In 1966 the total catch was 764.5 metric tons and worth $300,000 to fishermen, an amount less than half percent of the total catch value of the province's fisheries. The commercial species which belong to the family Pandalidae, in order of decreasing importance, are the "smooth pink" (Pandalus jordani), "pink" (P. borealis), "prawn" (P. platyceros), "sidestripe" (Pandalopsis dispar), "humpback" (Pandalus hypsinotus), "coonstripe" (P. danae). These, and three other species not generally recognized by fishermen, were described by Butler (1964).

In 1966, 712,700 kg, or 93.2 percent of the total catch, were taken by trawls. The main type in use is the beam trawl fished by small (9 to 12 m) combination vessels. Traps account for the remainder of landings, made up largely of P. platyceros and a smaller amount of P. danae. Descriptions of shrimp gear and fishing methods have appeared earlier (Anon. 1967; Butler, (in press); Cameron, 1960).

2 HISTORY OF THE FISHERY

A fishery was in existence before 1890 when shrimps were being taken near Victoria (Rathbun, 1900). Taylor (1912) reported seeing P. danae on sale in Victoria. According to reports, trawling began in English Bay in 1917, and probably shrimps were fished in Vancouver Harbour and inner Burrard Inlet before that date. Between world wars I and II, shrimp fishing was centered around Vancouver where the most valuable species was P. danae, and a smaller fishery near Prince Rupert was supported by P. borealis and Pandalopsis dispar (Berkeley, 1929).

During the last war, shrimp production dropped to a low level and began to expand again only after 1946. In the late 1940's, and until about 1952, practically all fishing was carried out for P. borealis near Vancouver, with small sporadic operations in northern areas. The next decade saw the development of several grounds on the east and west coasts of Vancouver Island, where P. jordani was the dominant commercial species (Butler, 1953a). During the same period, exploitation of stocks began and increased considerably in Chatham Sound near Prince Rupert.

3 EXPLORATORY FISHING

In 1953 and 1954, the Fisheries Research Board, with financial support from the Industrial Development Service of the Canadian Department of Fisheries, conducted exploratory trawling in most British Columbian coastal inlets (Butler, 1953b; Butler and Legaré, 1954; Butler and Dubokovic, 1955a). The most important find was a ground near Comox, east coast of Vancouver Island, which was fished within days after its discovery, and has remained productive to the present. A promising area in Barkley Sound, surveyed in June 1954, was not exploited until 1960. Although shrimp fishing started in Chatham Sound during 1952 or 1953, Board exploration in 1954 has assisted fishermen in their development of the ground.

Exploration along the outer coastal region in 1955 did not reveal economically usable shrimp stocks (Butler and Dubokovic, 1955b) and subsequent surveys off the west coast of Vancouver Island (Butler, 1959; Ronholt, 1964) had the same result. Finally in 1966, results of trawling in Queen Charlotte Sound indicated the presence of a stock of potential value (Heritage and Butler, 1967).

4 PRESENT STATUS OF THE SHRIMP FISHERY

Shrimp fishing grounds of British Columbia are shown in Fig. 1. The main trawling areas are in Burrard Inlet, Howe Sound, Stuart Channel, Barkley Sound, Chatham Sound and waters adjacent to Comox. Prawn trapping is carried out along the east coast of Vancouver Island, and in several mainland inlets from Smith Inlet to Howe Sound.

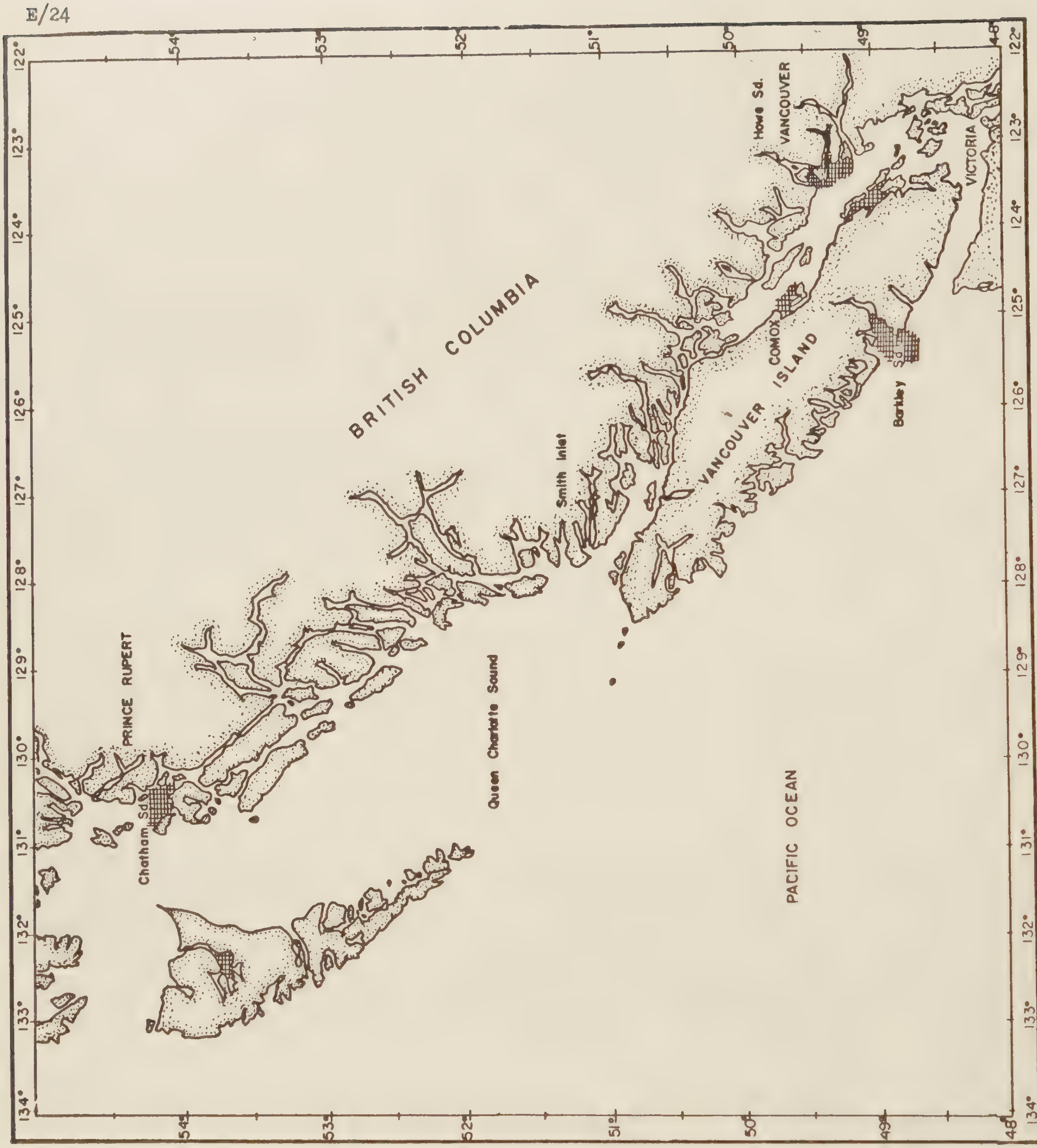

Fig. 1 Map of British Columbian coast showing shrimp fishing areas.

Total annual catches, from 1921 to 1966, are summarized in Table I. Until after world war II production was low, not reaching 110,000 kg. From 1947, catches increased steadily from 48,650 kg until they reached 572,100 kg in 1953. Apart from a slight drop in 1954, shrimp production has remained between 450 and 900 metric tons to the present. The higher level prevailing during the past 14 yr has been due largely to good yields from stocks of P. jordani on southern grounds of the province. In 1965 70.3 percent, and in other years since 1960 from 36.7 to 53.6 percent, of the total production has arisen from grounds surveyed by the Fisheries Research Board.

No estimate of the rate of exploitation of shrimp stocks is available. The assumption is however, that the prevailing rate is high on southern trawling grounds and that further fishing effort will not increase catches appreciably. Even so, grounds in English Bay and Howe Sound, near Vancouver, have produced steadily since the late 1940's without regulation or management. Along the whole coast stocks of P. platyceros available to trapping are believed to be utilized at a low level.

TABLE I

British Columbia shrimp and prawn landings
1921 to 1966

Years	Landings kg
1921-25	41,350
1926-30	50,750
1931-35	70,250
1936-40	49,000
1941-45	24,650
1946-50	127,350
1951-55	424,250
1956-60	676,600
1961	548,400
1962	755,950
1963	812,500
1964	478,300
1965	797,550
1966	764,450

5 PROSPECTS FOR FUTURE DEVELOPMENT

Favorable economic factors, including a high market demand for shrimps, encourage the expansion of the British Columbian fishery. It is expected that production will increase by 450 metric tons at least, within the next 10 yr. The increase will be achieved partly by greater utilization of known stocks, particularly of P. borealis in the vicinity of Prince Rupert. Also, prospects of finding new prawn trap grounds in coastal inlets, and outer coastal trawling areas for P. jordani, appear good.

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OSMOTIC BEHAVIOUR OF SHRIMPS AND PRAWNS IN RELATION TO THEIR BIOLOGY AND CULTURE

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Abstract

The prawns which are useful for cultural purposes belong mostly to the decapod families Penaeidae and Palaemonidae. Most penaeids are marine prawns which migrate to estuaries and brackish water in their young stages but go back to the sea to breed. A small number of them breed in coastal inlets and others are exclusively marine. Species of marine Palaemon are highly adaptable to lower salinities. The habitat of Palaemonetes ranges from sea water to fresh water while Macrobrachium is largely a fresh water genus. Species of Macrobrachium include those which migrate from fresh water to brackish water during the breeding season. The marine penaeids and palaemonids show capacities for hypo-osmotic regulation when in sea water and high powers of hyper-osmotic regulation in brackish and fresh water. They have not developed extreme specialization as fresh-water inhabitants in that their normal blood osmotic values are high as compared with old established fresh-water crustacea and they do not produce hypotonic urine for conserving salts. These features have endowed these prawns with unusual adaptational abilities to live in variable surroundings, although each species has its own optimal range. There is close correlation between euryhalinity and hyper-osmotic adaptation. There is a relationship between osmotic behaviour and temperature, and a combined influence of temperature and salinity is also in evidence. A fuller knowledge of isosmotic levels and critical evaluation of the influence of environmental conditions on osmotic and ionic behaviour would help to rationalize prawn and shrimp cultural practices. The paper discusses the distribution of prawns and shrimps, their value in culture, existing knowledge of their osmotic properties, influence of salinity and temperature on their physiology and related problems.

E/25

COMPORTEMENT OSMOTIQUE DES CREVETTES EN FONCTION DE LEUR BIOLOGIE ET DE LEUR ELEVAGE

Résumé

Les crevettes présentant un intérêt pour l'élevage sont essentiellement des Décapodes des familles Penaeidae et Palaemonidae. La plupart des Pénéidés sont des crevettes marines qui émigrent vers les estuaires et les eaux saumâtres durant leurs premiers stades de croissance, mais retournent à la mer pour se reproduire. Un petit nombre se reproduisent dans les criques, tandis que quelques-uns sont strictement marins. Les espèces du genre marin Palaemon sont extrêmement adaptables aux basses salinités. L'habitat des Palaemonetes va de l'eau de mer à l'eau douce, tandis que les Macrobrachium sont essentiellement liés aux eaux douces. Parmi les espèces du genre Macrobrachium, certaines émigrent des eaux douces aux eaux saumâtres à l'époque de la reproduction. Les Penaeidae et les Palaemonidae marins manifestent une aptitude à la régulation hypo-osmotique lorsqu'ils se trouvent en eau de mer et une forte capacité de régulation hyperosmotique en eaux saumâtres et douces. En outre, ils n'ont pas acquis une spécialisation extrême en tant qu'habitants des eaux douces, leurs valeurs osmotiques sanguines normales étant élevées par rapport à celles des crustacés vivant en eaux douces de longue date, et ils ne produisent pas d'urine hypotonique pour conserver les sels. Ces caractéristiques dotent ces crevettes d'extraordinaires capacités d'adaptation à divers milieux, quoique chaque espèce possède sa gamme optimale d'habitats. L'euryhalinité et l'adaptation hyperosmotique sont étroitement liées. Il existe un rapport entre le comportement osmotique et la température, et l'on a constaté aussi une influence combinée de la température et de la salinité. Il serait bon, pour rationaliser l'élevage des crevettes, d'approfondir la connaissance des niveaux iso-osmotiques et de procéder à l'évaluation critique de l'influence des conditions écologiques sur le comportement osmotique et ionique. La communication examine la répartition des crevettes, l'intérêt qu'elles présentent en pisciculture, les connaissances actuelles touchant leurs caractéristiques osmotiques, l'influence de la salinité et de la température sur leur physiologie et les problèmes connexes.

COMPORTAMIENTO OSMOTICO DE LAS GAMBAS Y CAMARONES EN RELACION CON SU CULTIVO Y BIOLOGIA

Extracto

Los camarones útiles para su cultivo son principalmente los Decápodos de las familias Penaeidae y Palaemonidae. Casi todos los peneidos son camarones marinos que emigran en sus fases juveniles a los estuarios y aguas salobres, en donde se desarrollan, volviendo después al mar para su reproducción. Un pequeño número de ellos se reproducen en las calas costeras, y otros pocos son exclusivamente marinos. Las especies de Palaemon marino son sumamente adaptables a las bajas salinidades. El habitat de Palaemonetes varía del agua del mar hasta el agua dulce, mientras que Macrobrachium es esencialmente un género de agua dulce. Hay especies de Macrobrachium que emigran de las aguas dulces a las salobres durante la época de reproducción. Los Peneidos y Palemónidos marinos muestran capacidad de adaptación hipoosmótica cuando viven en aguas marinas así como también una gran capacidad de adaptación hiperosmótica en aguas dulces y salobres. Como habitantes de aguas dulces no han desarrollado una gran especialización porque sus valores sanguíneos osmóticos normales son altos si se comparan con los crustáceos ya establecidos desde hace mucho tiempo en las aguas dulces, y no producen orina hipótica para conservar las sales. Estas características confieren a estos camarones una insólita facultad de adaptación para la vida en diferentes medios, a pesar de que cada especie tiene su propio habitat óptimo. Hay una estrecha correlación entre la eurihalinidad y la adaptación hiperosmótica. El comportamiento osmótico está relacionado con la temperatura y es también evidente una influencia combinada de esta última y la salinidad. Un conocimiento más profundo de los niveles isosmóticos y la valoración crítica de la influencia de las condiciones del medio ambiente en el comportamiento osmótico e iónico contribuiría a racionalizar las prácticas de cultivo de las gambas y camarones. En el trabajo se estudia su distribución y su valor para el cultivo, los conocimientos actuales de sus propiedades osmóticas, la influencia de la salinidad y de la temperatura en su fisiología y otros problemas análogos.

1 INTRODUCTION

A very considerable amount of information on the osmotic behaviour of Crustacea has accumulated in recent years and the mechanisms of osmotic regulation in them have been studied from various points of view. In the relation between osmotic behaviour and cultural practices of shrimps and prawns the principal factors that need examination are the distribution of these crustaceans in waters of varying salinities and the physiological adjustments observed in these animals, in an effort to rationalize our knowledge as to what species can thrive best under what conditions. It is interesting to note that there is a close relationship between their osmotic physiology and their possible cultural use because the latter is invariably based on species which have wide temperature and salinity tolerance.

Prawns and shrimps of commercial importance fall under the sub-order Natantia of the order Crustacea Decapoda and consists of three tribes: Penaeidea, Stenopodidea, and Caridea.

The two families under the first tribe are the Penaeidae and the Sergestidae and the species which are of interest in culture are those belonging to the well-known genera *Penaeus*, *Metapenaeus*, *Penaeopsis* and related forms. The sergestids which are exclusively marine, have not been subjected to large scale culture. The tribe Stenopodidea are also exclusively marine.

Under the tribe Caridea again we have several shrimps and prawns which are of interest from the point of view of culture. These are firstly the crangonids, particularly *Crangon crangon* (L.), and a large number of species belonging to the family Palaemonidae, particularly *Palaemon*, *Leander*, *Palaemonetes* and *Macrobrachium*. There are numerous related forms whose generic status is uncertain.

The family Atyidae are fresh water forms with a wide geographical distribution and mainly consisting of the genus *Caridina* and related forms. Although small in size they are of fishery interest in many countries, both directly, as in Japan, and indirectly as forage organisms for carnivorous teleosts in the tropics. They are not known from marine or brackish waters. Many other caridean families are marine stenohaline species having feeble powers of adaptation, and often the species have restricted ranges of distribution.

2 DISTRIBUTION OF PRAWNS

The vast majority of penaeid species are marine except that during the younger stages they migrate to creeks, backwaters and estuaries of varying salinities. They grow in the low salinity environment rather rapidly. This habit of penaeid prawns entering estuaries and growing there to their adult size, has been the basis of fish cultural and trapping practices in many parts of the world, more particularly in tropical regions like India where it is an established fishery practice (Panikkar, 1937; Gopinath, 1956; Menon, 1955). The question as to whether these prawns which grow in the coastal inlets attain sexual maturity and breed there, has been one of the most difficult problems to solve conclusively; but it seems fairly certain that most of the species do not breed in the brackish waters and that the sexual reproduction and the hatching of the penaeid nauplii from the eggs take place only in the open sea. Important departures to this rule amongst the penaeids are probably to be found in certain species of *Metapenaeus* (*M. monoceros* (Fabricius) and *M. bennettae* (as *M. mastersii*)) (Panikkar and Aiyar, 1939; Dakin, 1946). It is apparent that in spite of the essential marine habitat of the adult they are able to survive a very considerable amount of variation in the salinity of the external medium. This ability is shown particularly by the young stages. In fact early postlarvae and juvenile penaeids are a common feature of the Indian brackish-water fauna (Panikkar, 1937; Panikkar and Aiyar, 1937). The possibility of collecting these early penaeid stages and transplanting them for culture has been emphasized (Panikkar, 1952) and the practice is increasingly being adopted in many parts of the world, such as India, Malaysia, the Philippines and Japan.

The taxonomy and distribution of Palaemonidae of commercial importance has been extensively studied, notably by Kemp (1915) and Holthuis (1952), and the distribution of palaemonids in fresh and brackish water from the physiological angle has been reviewed (Panikkar, 1941: generic names under old nomenclature). The broad features are as follows: The genus Macrobrachium, which incidentally includes the largest commercial prawn known (Macrobrachium rosenbergii (de Man) = Palaemon carcinus), is a largely fresh-water genus although a few species are known to migrate to brackish water during breeding periods (Kemp. 1915; Panikkar, 1937). In India it is a common experience to find the larvae of species of Macrobrachium in brackish water, but only under low salinity conditions; the obvious inference is that the breeders move from fresh water to brackish water in the upper reaches of the estuarine system. The genus Palaemon, which for many years included species of Macrobrachium and Leander and which now includes many species formerly included in Leander, is found in the sea and brackish water. Species of Leander (sensu stricto) are found in marine, brackish water and fresh water environments, the latter condition especially in the tropics. The well-known European marine prawn is Palaemon serratus (Pennant) and the Black Sea prawn is Palaemon elegans (Rathke)(= Leander squilla (La)). Species of Palaemonetes are equally at home in sea water although their typical habitat is brackish water and fresh water. Isolated populations of brackish-water species of Palaemonetes have become established in fresh waters of different parts of the world, while some species of Palaemonetes are found on the sea coast presumably under low salinity conditions (Table I shows distribution of Indian shrimps and prawns).

3 OSMOTIC BEHAVIOUR OF PRAWNS

The adaptation of marine animals to brackish and fresh water is closely dependent on the development of osmoregulatory powers. Body fluids of most marine invertebrates generally have the same osmotic pressures as the surrounding sea water, but when they migrate to brackish waters they have to maintain their body fluids at levels higher than that of the dilute medium. The dilution of the body fluids by osmotic inflow is counteracted by active processes. The extent of the higher range to which they could regulate their body fluids is a variable factor amongst species belonging to a group, but the osmotic curve of an individual species is a distinct physiological criterion. The degree of hypertonicity which these animals can maintain is an index of their salinity tolerances. Good hypertonic regulators are able to reach lower salinity ranges and, in rare instances, even fresh waters, as exemplified by Palaemonetes varians (Leach). Animals which do not have this power of regulation are spoken of as marine stenohaline forms and they are unable to enter brackish and fresh waters.

The vast majority of the sergestids, stenopodids and several families of Caridea are marine stenohaline crustaceans. Under this category come the well-known genera Acetes, Processa and Pandalus, which are extremely sensitive to salinity changes and do not easily lend themselves to large scale culture.

Many palaemonids and penaeids, on the other hand, are endowed with high powers of osmoregulation and are able to maintain the concentration of their body fluids well above that of their surroundings. (Fig. 1)

The palaemonid prawns which live in sea water are not merely good regulators when in dilute sea water but they are endowed with the remarkable property of hypo-osmotic regulations when in sea water. They exhibit homoiosmotic behaviour which is one of the most advanced mechanisms ever perfected by marine invertebrates. This finding (Panikkar, 1939; 1940a) opened up much further work on hypo-osmotic regulation and has been dealt with in detail (Panikkar, 1941). It has clearly been established that Palaemon serratus is capable of maintaining body fluids at a much lower concentration than the external medium, e.g. at 2.6 to 2.9 percent NaCl in fully marine waters of 3.5 percent NaCl. A much more advanced regulatory power, almost equal to that of the marine teleosts, was found in Palaemonetes varians which has a range of distribution from sea water to almost fresh water. Following the osmotic studies, these prawns have been critically examined for their ionic regulations by Parry (1954) and we have now a much clearer idea of the way in which this regulation is achieved. The point of special

TABLE I

Distribution of Indian Commercial Prawns

Species (cultivated species with asterisk)	Habitat
* *Penaeus indicus*	Marine: young in brackish water
* *Penaeus carinatus*	Marine and inshore in young stages
Parapenaeopsis stylifera	Purely marine
Parapenaeopsis sculptilis	Marine and estuarine
* *Metapenaeus dobsoni*	Marine: young in brackish water
* *Metapenaeus monoceros*	Inshore and brackish water
* *Metapenaeus brevicornis*	Marine, brackish water, nearly fresh water
Leander tenuipes	Marine and inshore, spawns in sea
* *Leander styliferus*	Inshore and estuarine. Breeds in estuaries and sea
Leander fluminicola	Fresh water
* *Macrobrachium rosenbergii*	Fresh water, breeds in brackish water. Larvae require saline water
Macrobrachium malcolmsonii	Fresh water, breeding migration doubtful
Macrobrachium mirabile	Fresh water, breeds in brackish water
Macrobrachium lamarrei	Fresh water and brackish water
Macrobrachium idae	Fresh water) Probable movement of breeders to upper estuarine reaches
* *Macrobrachium rude*	Fresh water)
Caridina gracilirostris	Fresh water

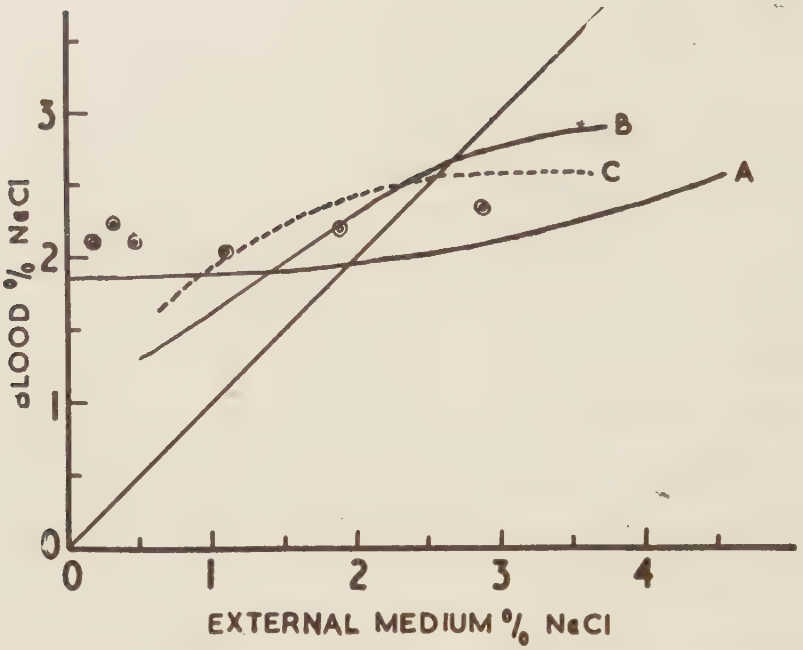

Fig. 1 Osmotic pressure (in % NaCl) of the blood of (A) Palaemonetes varians. (B) Palaemon serratus and (C) Palaemon elegans (dotted line) in different concentrations of the external medium measured under experimental conditions. Straight line indicates where points would fall if external and internal media were isotonic. Circles represent osmotic pressures (mean values only) of Palaemonetes from water of different salinities in its natural habitat. (After Panikkar, 1941).

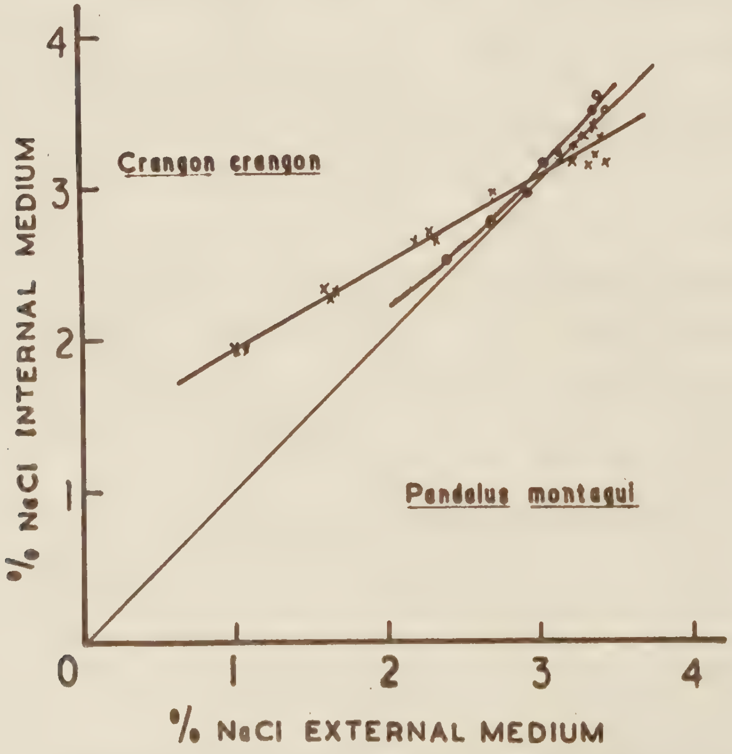

Fig. 2 Osmotic pressure of the blood of Crangon crangon and Pandalus montagui in different concentrations of sea waters under experimental conditions.

X———X———X = Crangon
O———O———O = Pandalus

interest that emerges from all these studies is that the urine is isotonic and that the normal osmotic value of these prawns acclimatizing in fresh water is much higher than that of the more specialized fresh water Crustacea exemplified by astacoids (Astacus). It is probably the very high normal osmotic value in these palaemonids and the absence of a fresh water stenohaline adaptation, involving production of large amounts of hypotonic or very dilute urine, which has enabled them to be distributed in sea water, brackish water and fresh water. The structure of the excretory system in these prawns as compared with that of Astacus confirms this view (Panikkar, 1941, as Potamobius).

Taking now the case of penaeids, it is interesting to note that hypo-osmotic regulation has also been established in Metapenaeus monoceros (c.f. Panikkar and Viswanathan, 1948) and in a number of other penaeids in India (Panikkar, 1950) and in P. aztecus Ives and P. duorarum Burkenroad in America (Williams, 1960). From the results on Metapenaeus it is clear that the osmotic regulation is largely achieved through chloride regulation (Panikkar and Viswanathan, 1948). The degree of hypotonicity is less than the values for palaemonids. From the evidence on the distribution of penaeids presented by a large number of authors, particularly Gunter (1964, and many earlier papers) and his school in the United States, and various authors in India, adaptation to lower salinity is highly developed in the younger stages, and, consequently, the young and juvenile prawns are more widely distributed in the estuarine and brackish-water environment than the full grown adults. The apparent conclusion is that osmoregulation in dilute media is less effective in the full sized individuals and probably particularly in the reproductive phases, which necessitates their migration back to the sea. In the case of fresh-water prawns of the genus Macrobrachium there is a comparable migration over a lower range of salinities, i.e., they have to move to brackish water to maintain their body fluid concentration at a sufficiently high (hypertonic) level.

The well-known European shrimp Crangon crangon is also slightly hypotonic when in sea water, but the degree of hypotonicity is very much less than in the Palaemonidae and Penaeidae investigated and the range of tolerance in brackish water is also correspondingly less. The study of Broekema (1941) has brought interesting evidence on the distribution of Crangon in the inlets of the Netherlands.

Pandalus montagui, the North Sea marine prawn, is nearly isotonic in sea water and is a poor regulator in reduced salinities, showing an almost isosmotic curve. Comparative data on Crangon and Pandalus from the author's observations, previously unpublished, are given in Fig. 2.

4 THE RELATION OF OSMOTIC BEHAVIOUR TO CULTURAL PRACTICES

The process of osmotic regulation of marine and estuarine prawns, as is now understood, has clearly shown the need for certain features of the environment for the successful penetration of these organisms into waters of lower salinity. The work of Krogh (1938, 1939) and other investigators has established that active absorption of ions, particularly chlorides, forms an essential feature of the adaptational process and that it is the active transport of ions through the membranes separating the internal and external media which enables many aquatic animals to maintain steep osmotic gradients. This is particularly to be noted in fresh water and brackish water. Other factors at play are the reduction in the permeability of the body walls and the ability of the renal organs to pump out the excess water with the minimum loss of salt.

It is apparent that the penaeid and palaemonid prawns growing under low salinity or fresh-water conditions are able to survive only if there is sufficient chloride in the surroundings to enable the blood concentration to be maintained at a high level. It is important to note that for species like Palaemonetes the mechanism is effective even in very low salinities. Survival becomes possible for these animals even under artificial conditions, provided that the availability of the chloride ions is assured. The active process is functional even when the ions are present only in exceedingly minute quantities, a process which some authors have called "anion-atmung".

In those species of Macrobrachium which migrate from fresh to brackish water in the breeding season, the most important limiting factor is again the concentration of chloride ions in the medium. It is uncertain at present whether this applies to the ovigerous females, the newly hatched larvae or both. Ovigerous females of Palaemon serratus have higher osmotic values than non-ovigerous specimens (Panikkar, 1941); this suggests that they may need higher salinities in their surroundings, and the same may apply to species like M. rosenbergii. It is not clear from the available evidence whether there is any impairment of regulatory mechanism in ovigerous females. The findings of Rajyalakshmi (1960) and Ling and Merican (1961) tend to show that later development and larval stages require saline water.

The large number of coastal and estuarine prawns distributed in many parts of the world have differences in their osmotic adaptation, particularly as regards their points of isotonicity (Table II). In the perfection of cultural practices, knowledge of the isotonic conditions for these prawns will be of very considerable value, because it is reasonable to expect that the osmotic work required is minimal where the external and internal media are at equilibrium. Under such conditions the oxygen requirements of the organisms will also be low and, correspondingly, also the natural mortality due to low oxygen tension. It is reasonable to assume that under isosmotic conditions the largest number of organisms could be cultured in a given volume of water. In this connection the results obtained by Lofts (1956) on the respiratory rate of the prawn Palaemonetes varians are of great interest. It was found from a series of measurements of the oxygen consumption of this prawn in different salinities that the lowest rate occurred under isotonic saline conditions. A point of further interest is the fact that the isotonic point is variable even within the same species if different populations are involved. Lofts found that in the populations of P. varians from saline areas the isotonic point and minimum respiratory rate was at 26 ppm NaCl, whereas in another population which had become isolated in fresh water the minimum respiratory rate was at 6 ppm NaCl, which obviously was at a condition of hypertonicity.

The homoiosmotic Indian prawn Metapenaeus monoceros from the brackish-water habitat has a minimal rate of respiration in 50 percent sea water, with increase in higher and lower salinities. On the other hand the same species from the marine habitat showed the minimal rate in sea water (Rao, 1958).

5 ROLE OF TEMPERATURE AND COMBINED EFFECTS OF TEMPERATURE AND SALINITY

Most of the prawns and shrimps useful for culture are not merely euryhaline, as discussed before, but also eurythermal. The indications are that cultural practices are easier at temperatures above 15°C. The possible influence of temperature on osmoregulation and its bearing on problems of crustacean distribution have been pointed out (Panikkar, 1940b). In the Decapoda Natantia the distribution patterns indicate that temperate marine species tend to become inhabitants of brackish and fresh water under tropical conditions. There are many instances of marine species of colder latitudes being represented by brackish-water and fresh-water species in the tropics. This peculiarity of distribution has been noticed by many workers, but the suggestion made that the influence of temperature on the osmotic behaviour may provide a probable answer is one worthy of more vigorous pursuit (Verwey, 1957). The exact mechanism of this is not clear, although lower osmotic values have been encountered in individuals acclimatized to high temperatures.

In the European shrimp Crangon crangon, Broekema (1941) found that adults seek higher salinities in cold weather and lower salinities in warm weather, and the young in summer tolerate lower salinities than the adults. This animal is similar to the European prawn Palaemon serratus, being a hypo-osmotic regulator in sea water and a good hyper-osmotic regulator in brackish water. Under constant salinities, there was an increase in the blood osmotic pressure with a fall in temperature. The same type of seasonal cycle in osmotic behaviour of palaemonid prawns was found on the British coast by Panikkar (1940b) who interpreted it in the light of the known distribution of

TABLE II

Isotonic levels of Marine and Estuarine Shrimps and Prawns

Species	Isosmotic Point (expressed as % NaCl): Approximate	Author
Pandalus montagui	3.50	Panikkar (this paper)
Crangon crangon	2.15 - 2.3 3.1	Broekema (1941) Panikkar (this paper)
Palaemon serratus	2.5	Panikkar (1940a)
Palaemon elegans	2.4	Panikkar (1941)
Palaemonetes varians	2.0	Panikkar (1939)
Penaeus aztecus	2.51	Williams (1960)
Penaeus duorarum	2.75	Williams (1960)
Metapenaeus monoceros	2.63	Panikkar and Viswanathan (1948); Panikkar (unpublished)

Crustacea. Discussing these results from the evolutionary point of view Huxley (1942) considers the temperature-salinity distribution relationship of Crustacea as one of "pre-adaptation".

Recent work of Williams (1960) has again confirmed this trend with reference to the penaeids on the North Carolina coast of America. Both Penaeus aztecus and P. duorarum inhabit a wide range of salinities and are hypotonic in sea water. He has brought out the interesting point that regulatory ability of both juveniles and adults is impaired at low temperatures (8.7 - 8.8°C) and the blood tends to become isotonic. The survival of these prawns was better in higher salinities at low temperatures.

There are many questions which could be asked. Is the tendency for the blood to become isotonic at low temperatures due to lack of efficiency in the osmoregulatory mechanism or increased ability to establish equilibrium? Recent work of Schlieper (1964) has yielded information on the possible effects of other ionic factors, such as potassium in tissue adaptation. These are certainly fields in which much further work is required, and it is important to emphasize that apart from the individual effects of temperature or salinity there is a need to take into account their combined effects. The problems of temperature-salinity relationship and the different roles of genetic and non-genetic adaptation have been extensively reviewed by Kinne (1963; 1964).

6 ROLE OF CALCIUM AND OTHER IONS

Moulting behaviour is an essential feature of arthropod growth. The crustacean exoskeleton has a high calcium component, and it has been shown by many workers that there is a close relationship between calcium metabolism, growth, moulting and osmotic pressure (Robertson, 1937; Panikkar, 1941). From the point of view of cultural practices the availability of sufficient calcium in the surroundings has to be taken into consideration. Owing to the importance of calcium in regulating the permeability of membranes, the osmo-regulatory mechanism breaks down in calcium-deficient surroundings. Quick growth and moulting of the younger stages become impossible in external media where the calcium supply is inadequate. Unpublished obvservations of the author show that in living aquatic Crustacea it is impossible to achieve a calcium-free state owing to the residual calcium in the body walls, but osmotic efficiency is reduced in both hyper-osmotic and hypo-osmotic gradients when Palaemon serratus is kept in calcium-free sea water. As the calcium content of the crustacean moult is high, lack of calcium in the surroundings may affect the frequency of moulting and play a major part in the growth process.

7 CONCLUSION

Highly developed osmoregulatory powers in marine prawns and shrimps belonging to the families Penaeidae and Palaemonidae have enabled them to withstand considerable changes in the external medium and to move freely from sea water to brackish water or even to fresh water. In the general biology of several species these movements are obligatory and for some fresh-water palaemonids migration to brackish waters is necessary. In the selection of species for culture, commercially valuable prawns and shrimps with the widest range of adaptation should be chosen, because they are most likely to tolerate the conditions imposed upon them. There is a fairly good correlation between the cultural practices now developed and the physiology of the crustacea concerned, but further application of physiological knowledge would lead to the selection of environments to obtain higher yield and lower natural mortality. It cannot be said that the existing knowledge of the subject is comprehensive enough for immediate application and much further work is needed in not only collecting the basic information on osmotic behaviour but also assessing the combined influence of factors like temperature and salinity on osmotic and ionic regulation.

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RELACIONES ENTRE LARGOS Y PESOS DE CAMARONES CAPTURADOS EN LA PLATAFORMA CUBANA

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Extracto

Se determinan algunas relaciones biológicas con interés práctico. Se presentan las relaciones largo total - largo cefalotórax, largo total - peso; y los factores de conversión de peso de cola de camarón y peso de camarón seco a peso de camarón entero fresco para las especies Penaeus duorarum y Penaeus schmitti.

LENGTH AND WEIGHT RELATIONSHIPS OF SHRIMP CAUGHT ON THE CONTINENTAL SHELF OF CUBA

Abstract

Certain biological relationships of practical interest are determined. The ratios for total length/size of cephalothorax and total length/weight are given; conversion factors for changing weight of shrimp tails and weight of dry shrimp into weight of whole fresh shrimp for the species Penaeus duorarum and Penaeus schmitti are given.

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RAPPORT ENTRE LA LONGUEUR ET LE POIDS DES CREVETTES CAPTUREES SUR LE PLATEAU CONTINENTAL CUBAIN

Résumé

Les auteurs ont établi quelques relations biologiques présentant un intérêt pratique. Ils décrivent les rapports longueur totale/longueur du céphalothorax et longueur totale/poids et indiquent pour les espèces Penaeus duorarum et Penaeus schmitti, les coefficients de conversion pondérale des queues de crevettes et des crevettes sèches en crevettes entières fraîches.

1 INTRODUCCION

En este trabajo se han determinado las relaciones: largo peso, largo cefalotórax -largo total, y peso cola - peso total de las especies de camarón Penaeus duorarum y P. schmitti.

Los datos que fueron utilizados para estas determinaciones provienen de muestras tomadas a bordo del barco "CAMARON I" por la Sección de Camarones del CIP durante el período de abril a diciembre de 1965 y también de ejemplares estudiados en julio de 1965 en la Cooperativa de Manzanillo, especialmente para las relaciones peso de camarón cola- peso de camarón entero fresco y peso de camarón seco - peso de camarón entero fresco.

2 RELACIONES

2.1 Relación largo cefalotórax - largo total

Los largos del cefalotórax (Lc_2) son medidos a partir de la base de la escotadura post-orbital hasta el punto medio dorsal del borde exterior del cefalotórax.

Los largos totales (Lt_2) son medidos desde la base de la escotadura post-orbital hasta el borde posterior del útlimo somito abdominal en su punto medio dorsal.

Las mediciones fueron realizadas con un pie de rey y aproximadas al milímetro más próximo.

Los datos fueron agrupados por especies y sexos y clasificados en clases de un milímetro según el largo de cefalotórax (Cuadro I).

Las distribuciones de los largos totales de cada sexo y especie en cada clase de Lc_2 son presentados en la Fig. 1.

La Figura sugiere que existe una relación entre el largo total y el largo del cefalotórax independientemente del sexo o especie. La relación parece ser curvilínea.

Con todo, las observaciones pueden ser ajustadas por dos líneas rectas, una para los puntos correspondientes a los valores menores de Lc_2, por ejemplo, inferiores o igual a 34 mm, y otra para los valores superiores.

Para obtener las ecuaciones de esas rectas utilizamos las técnicas de regresión lineal.

Se calcularon las dos rectas de regresión para cada grupo de sexos y especies y no se verificaron diferencias significativas entre sexos y especies.

Las rectas que por tanto se ajustan a los datos son:

Para Lc_2 menores o igual a 34 mm $Lt_2 = 7{,}78 + 3{,}09\ Lc_2$

Para Lc_2 mayores de 34 mm $Lt_2 = 28{,}77 + 2{,}41\ Lc_2$

La relación largo cefalotórax - largo total, puede tener la importancia práctica de poder facilitar la medición de los largos del camarón. Así, se hace más rápida la medición del largo del cefalotórax que la del largo total; largos del cefalotórax pueden ser, siempre que sea necesario, convertidos a largo total por medio de las ecuaciones dadas anteriormente.

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CUADRO I

Distribución de largos de cefalotórax y largo total

Lc_2 P. medio	Penaeus duorarum				Penaeus schmitti			
	Lt_2 Media	Frec.	Lt_2 Media	Frec.	Lt_2 Media	Frec.	Lt_2 Media	Frec.
	♂		♀		♂		♀	
13	46,5	4	44,3	7	47,1	1	----	--
14	50,1	8	48,2	5	50,6	3	----	--
15	52,2	24	51,5	17	55,0	7	53,9	17
16	54,9	18	54,7	25	58,9	17	57,8	32
17	59,9	19	58,7	23	61,6	31	61,4	36
18	62,9	52	61,8	43	65,0	67	64,8	85
19	65,7	100	64,9	72	68,3	74	67,8	100
20	69,0	168	68,3	101	71,7	98	71,4	108
21	72,0	157	71,2	126	74,9	73	74,2	112
22	74,4	148	74,3	140	77,9	68	77,0	73
23	78,5	131	78,8	122	81,1	35	80,1	81
24	81,8	102	80,8	117	83,9	38	83,3	32
25	84,0	61	83,4	103	87,0	21	86,2	28
26	87,6	40	86,2	65	91,9	13	90,0	26
27	90,7	28	89,1	74	93,7	18	92,4	20
28	92,7	21	92,7	63	97,1	18	99,4	16
29	96,5	14	95,7	65	101,4	17	97,9	11
30	97,7	9	99,3	50	104,5	21	100,7	13
31	104,0	1	101,4	43	105,8	40	104,9	13
32	105,7	3	104,3	40	109,2	69	107,9	16
33	----	--	106,7	42	110,9	85	107,9	16
34	107,9	35	110,9	16	113,8	63	111,6	20
35	----	--	112,7	51	116,7	58	112,4	31
36	----	--	113,9	23	117,9	27	114,9	25
37	----	--	117,2	23	121,7	18	117,0	32
38	----	--	119,3	24	124,5	10	119,2	43
39	----	--	121,3	8	124,0	2	121,9	28
40	----	--	125,2	11	----	--	123,7	33
41	----	--	127,3	9	128,3	3	126,3	22
42	----	--	130,3	10	----	--	129,7	24
43	----	--	131,0	2	----	--	131,4	17
44	----	--	135,0	4	----	--	134,4	15
45	----	--	134,0	1	----	--	135,9	12
46	----	--	142,0	2	----	--	139,1	7
47	----	--	----	--	----	--	138,8	4
48	----	--	----	--	----	--	144,0	9
49	----	--	151,0	1	----	--	144,4	9
50	----	--	----	--	----	--	149,0	1
51	----	--	----	--	----	--	153,0	1
52	----	--	----	--	----	--	152,0	2
53	----	--	----	--	----	--	160,0	1

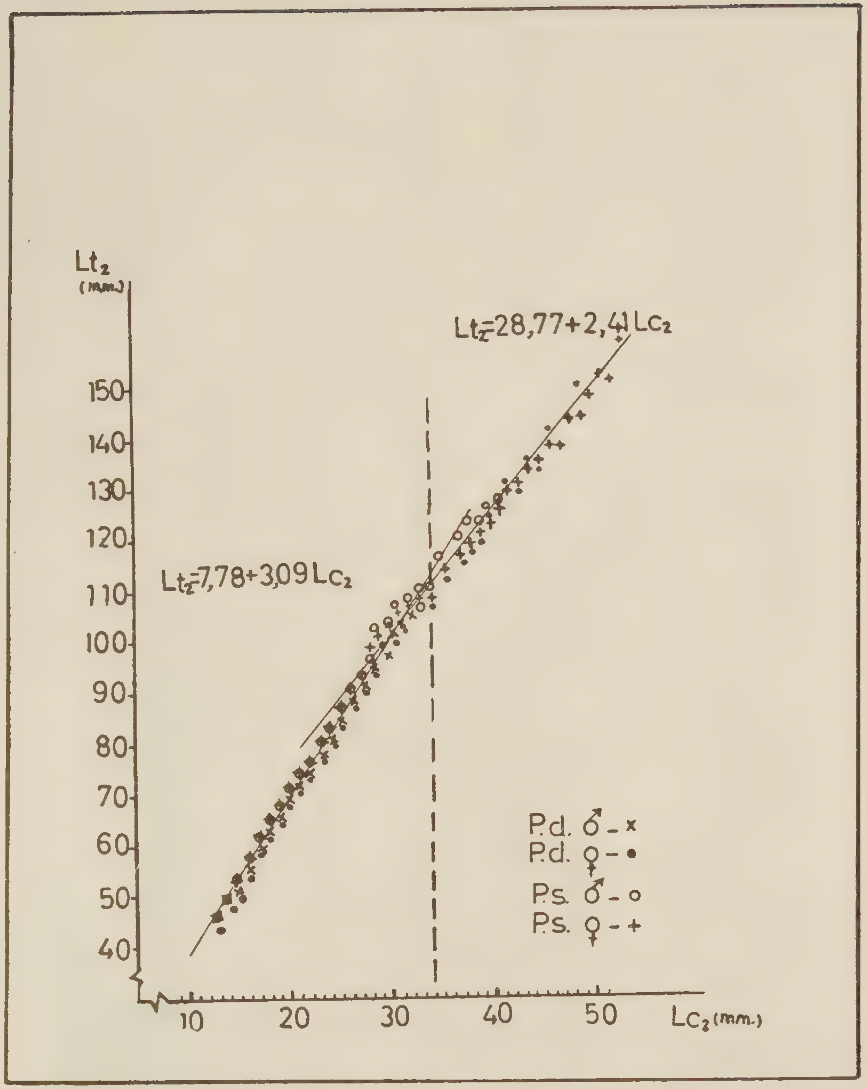

Fig. 1 Relación largo total-largo cefalotórax.

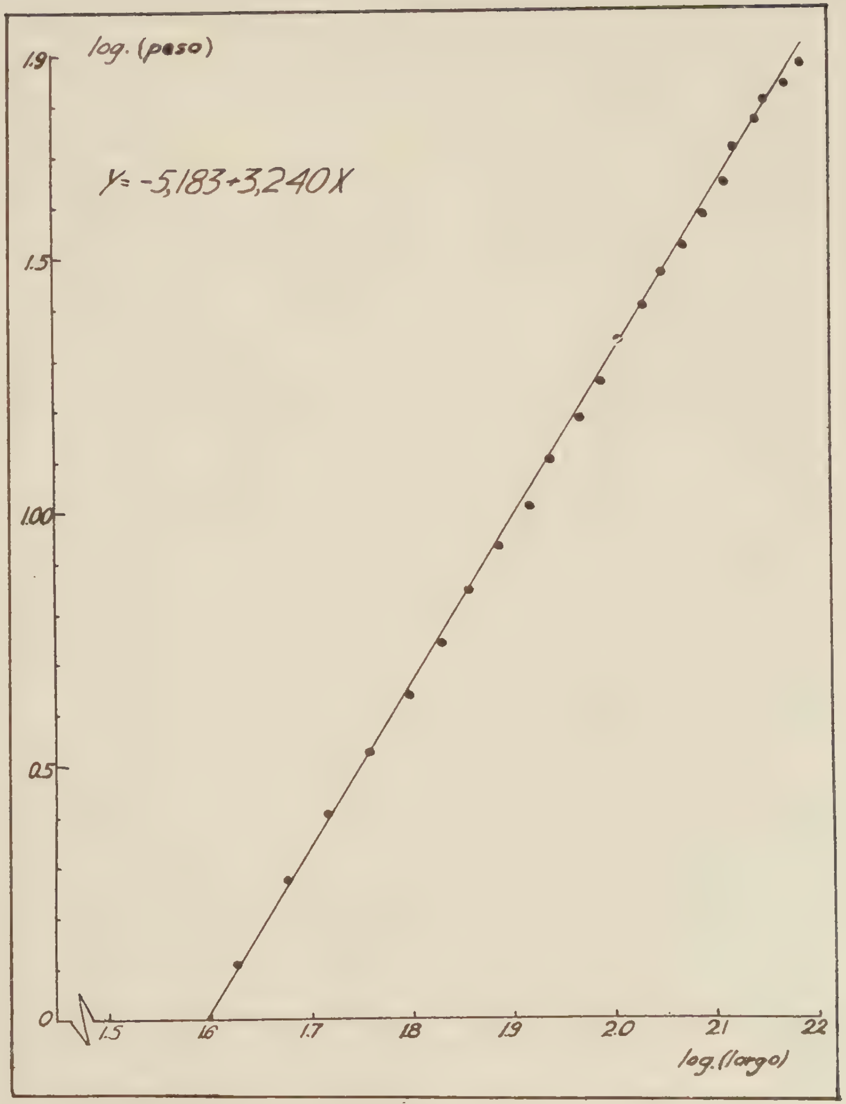

Fig. 2 Relación logaritmo peso - logaritmo largo.

2.2 Relación largo total - peso camarón entero

Los camarones en las muestras fueron clasificados por sus largos totales en clases de 5 mm, con puntos medios de 43 mm, 48 mm, 53 mm, etc. En cada muestra los camarones de cada clase fueron pesados en conjunto (Cuadro II).

La representación gráfica de los logaritmos de los pesos medios de cada clase contra los logaritmos de los puntos medios de las clases correspondientes sugiere que una línea recta se ajusta bien a los puntos observados (véase Fig. 2).

La ecuación de la recta calculada por los métodos de regresión lineal ponderada fue:

$$Y = -5{,}183 + 3{,}240\ X$$

donde, "Y" es el logaritmo del peso y "X" es el logaritmo del largo.

La ecuación puede ser presentada en términos del peso (P) y del largo (L):

$$P = 0{,}000007\ L^{3{,}240}$$

donde "P" es expresado en gramos y "L" en mm (véase Fig. 3).

La importancia práctica de la relación largo - peso es evitar el pesaje de camarones, operación siempre difícil de realizar especialmente a bordo de los barcos. Con el uso de esta relación se pueden convertir en peso los largos observados y, por tanto, transformar, por ejemplo, una composición por largos en una composición por pesos.

En muchas situaciones no será necesario obterner los pesos, ya que bastará conocer cantidades proporcionales a los mismos. En tales casos la conversión será simplificada, siendo suficiente calcular las cantidades $L^{3{,}240}$ de la ecuación de la sección 2.2.

Para el análisis de las poblaciones de camarones puede ser útil tener una relación entre el peso y el largo, similar a la ecuación dada anteriormente, pero con el exponente de "L" igual a 3. Nos referimos por ejemplo a la posibilidad de utilizar la ecuación de crecimiento de Bertalanffy y los métodos y tablas existentes para los cálculos sobre capturas máximas sostenibles, etc. Así, determinamos también la ecuación:

$$P = 0{,}000019\ L^3$$

Para apreciar el ajuste de esta ecuación a los datos observados presentamos la Fig. 4. Esta ecuación subestima los pesos de los camarones menores y sobrestima los pesos de los camarones mayores. La utilización de esta ecuación deberá ser hecha teniendo en consideración estas diferencias.

Para su comparación presentamos enseguida algunas relaciones obtenidas por otros autores:

Relación largo - peso de la forma

$$P = cL^n\ ;$$

Especie	Valor de n	Autor	
Leander styliferus = *Palaemon styliferus*	2,87	Kunju, M.M.,	1956
Leander serrifer = *Palaemon serrifer*	3,25	Ynowye, A.,	1949
Pandalus kessleri	3,14	Kubo, I.,	1951
Metapenaeus joyneri	2,95	Ykematsu, W.,	1955
Hymenopenaeus muelleri	3,20	Angelescu, V. y E.E. Boschi,	1959

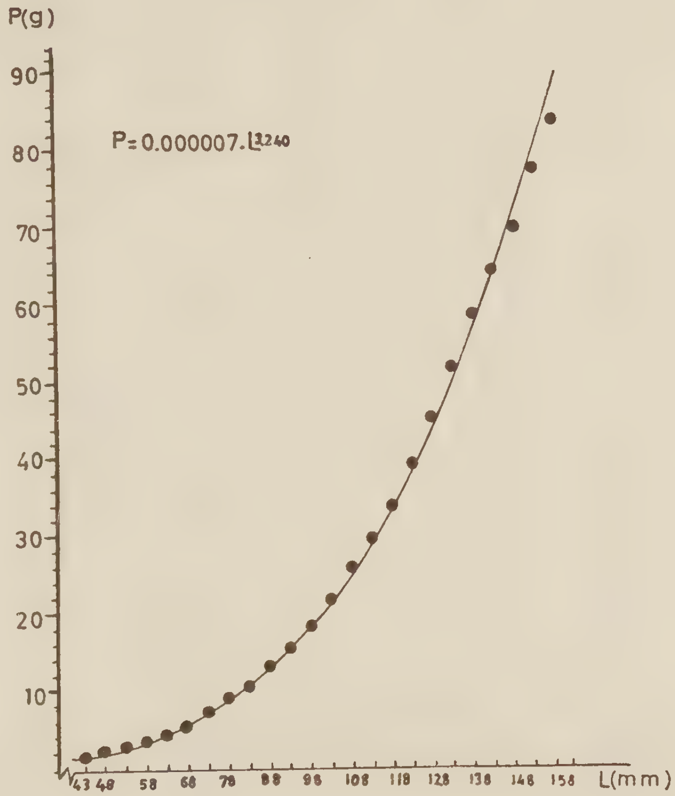

Fig. 3 Relación largo-peso.

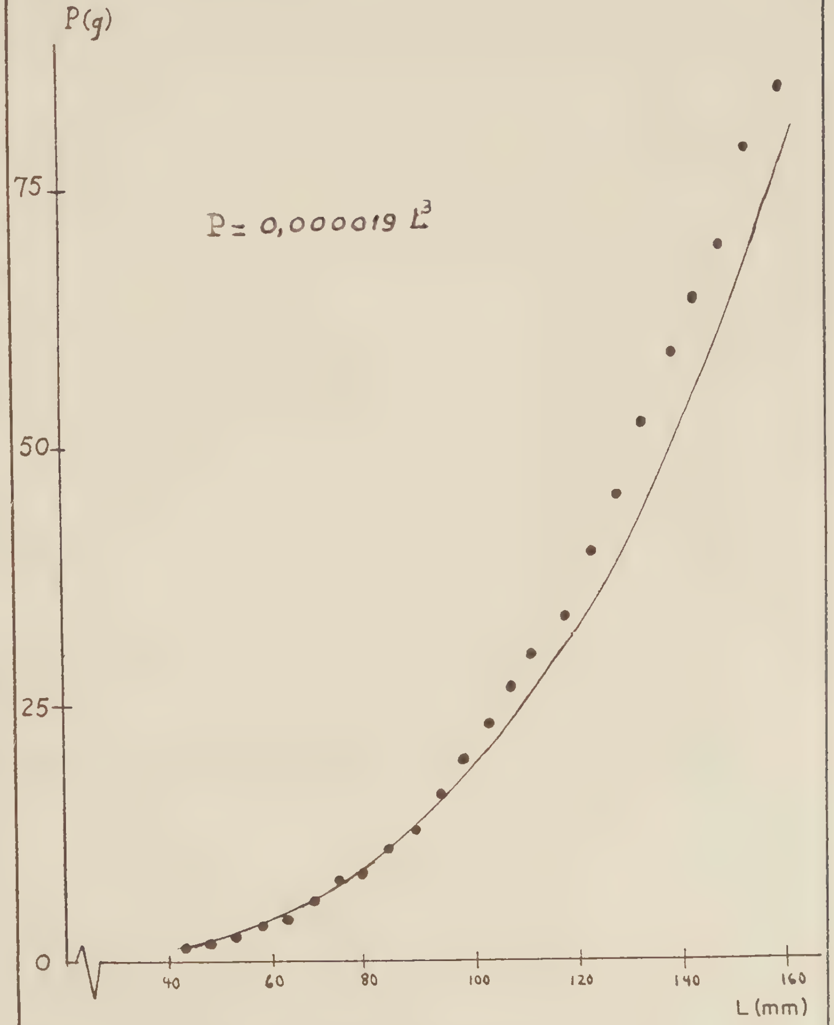

Fig. 4 Relación largo - peso con n = 3.

CUADRO II

Distribución de largos totales y pesos

Largos	Pesos		Largos	Pesos	
P. Medios	Frec.	Medias	P. Medios	Frec.	Medias
43	7	1,3	103	154	21,7
48	23	1,9	108	229	25,6
53	92	2,6	113	260	29,6
58	118	3,4	118	183	33,6
63	290	4,5	123	102	39,1
68	595	5,6	128	68	45,0
73	670	7,1	133	42	52,0
78	495	8,8	138	25	58,7
83	404	10,6	143	16	64,0
88	223	12,8	148	6	69,8
93	171	15,3	153	3	77,3
98	149	18,1	158	1	84,0

2.3 Factores de conversión de peso de camarón cola y camarón seco a peso de camarón entero fresco

Para la obtención de estas relaciones más que una muestra al azar nos interesa que la muestra cubra la diversidad de pesos posibles. Así, los datos fueron obtenidos tomando camarones de diversas tallas. Los métodos de separar las colas y de secar los camarones fueron usados por los pescadores. El camarón seco se obtiene cociéndolo entero en agua con sal, y posteriormente secándolo al sol; después de seco se saca el carapacho.

Los camarones fueron agrupados por especies y sexos y clasificados por los largos totales en clases de 5 mm. Los pesajes se realizaron en grupos de 10 camarones y cuando su número era inferior a 10 se pesaron todos ellos.

La representación gráfica de los pesos enteros contra los pesos de camarón cola y camarón seco muestra una tendencia lineal (Figs. 5 y 6). Las ecuaciones de regresión lineal pasando por el origen fueron calculadas y se presentan a continuación:

	P. duorarum		P. schmitti	
	♂	♀	♂	♀
Camarón cola (X) a Camarón entero (Y)	Y=1,59X	Y=1,73X	Y=1,61X	Y=1,69X
Camarón seco (X) a Camarón entero (Y)	Y=4,53X	Y=3,92X	Y=4,78X	Y=4,04X

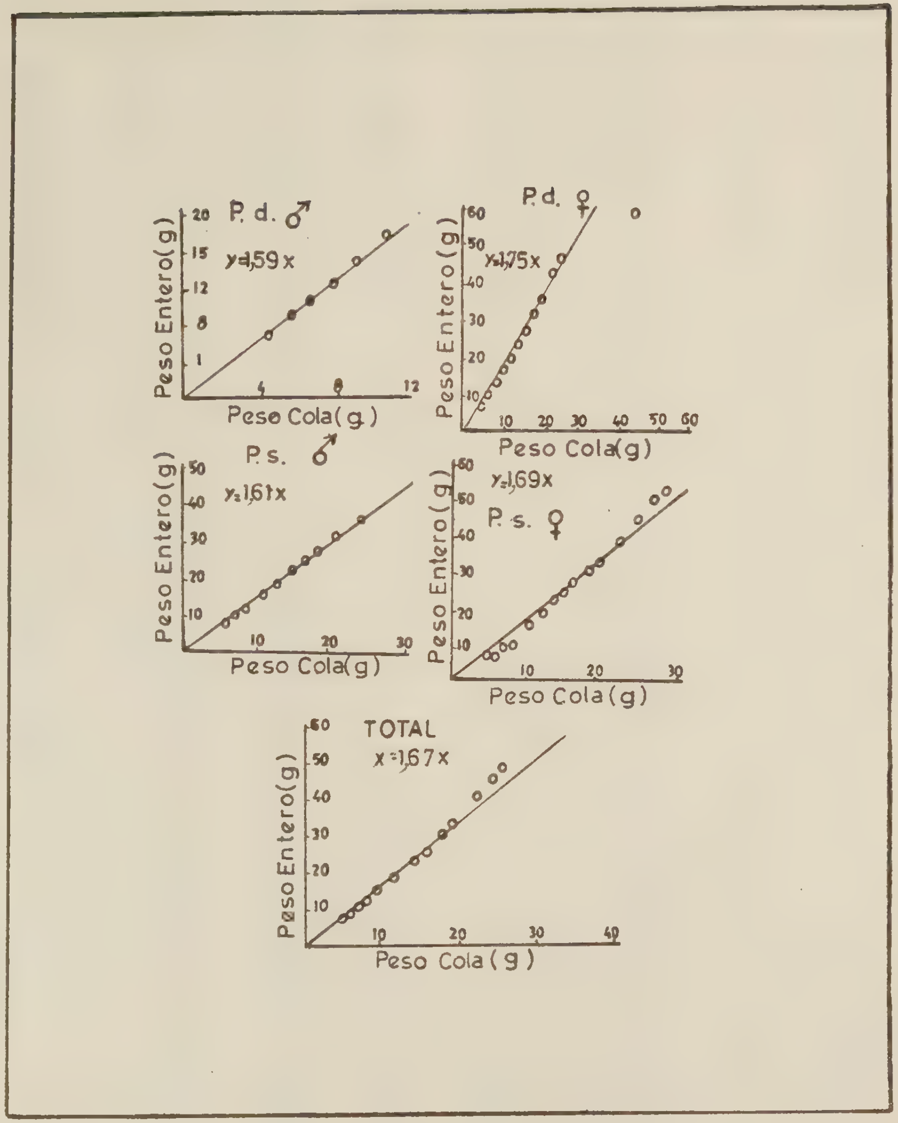

Fig. 5 Relación peso camarón cola-peso entero.

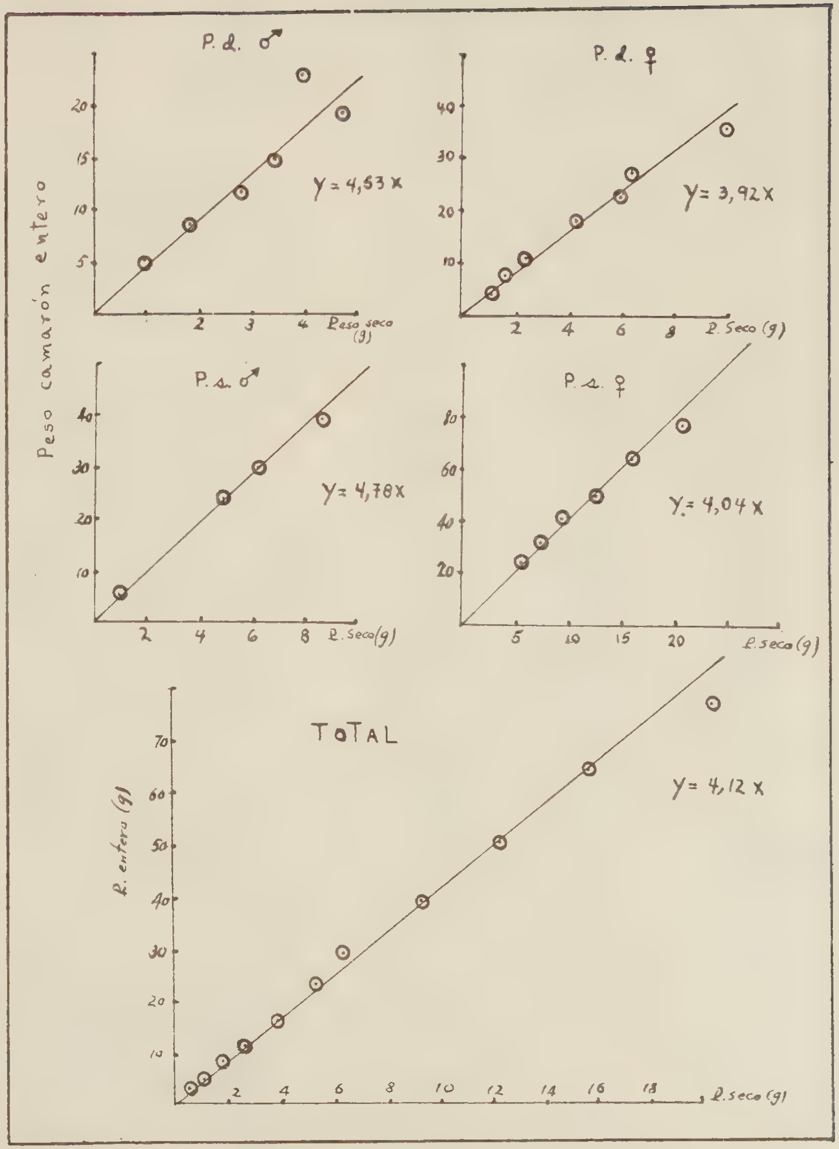

Fig. 6 Relación peso camarón seco - peso entero fresco.

Las rectas de regresión, que pasan por el origen y que fueron obtenidas sin distinción entre sexos y especies, son:

$Y = 1{,}67\ X$ para camarón cola-camarón entero

$Y = 4{,}12\ X$ para camarón seco-camarón entero fresco

Las relaciones peso cola - peso entero fresco y peso camarón seco - peso entero fresco son útiles ya que permiten obtener los factores de conversión correspondientes, que deberán ser aplicados a los desembarcos de camarón en cola o seco a fin de convertir esos totales en camarón entero fresco y poder adicionarlos a los desembarques de camarón entero.

Los factores de conversión son los coeficientes de regresión cuando las rectas pasan por el origen. Así, en Cuba se adopta como factor de conversión de peso cola a peso entero fresco el valor 1,67 y el factor de conversión de peso de camarón seco a peso entero fresco el valor 4,12.

3 CONCLUSIONES

(1) Las relaciones entre largo total y largo de cefalotorax de las dos especies de camarones - P. duorarum y P. schmitti - fueron calculadas obteniéndose:

$Lt_2 = 7{,}78 + 3{,}09\ Lc_2$ para valores de Lc_2 inferiores o iguales a 34 mm

y

$Lt_2 = 28{,}77 + 2{,}41\ Lc_2$ para valores de Lc_2 superiores a 34 mm

(2) El peso de los camarones en el Golfo de Guacanayabo puede ser obtenido a partir del largo total por medio de la relación:

$$P = 0{,}000007 . L^{3{,}240}$$

(3) El factor para convertir el peso de cola de camarón en peso de camarón entero fue determinado obteniéndose el valor 1,67.

(4) El factor para convertir el peso de camarón seco en peso de camarón entero fue calculado obteniéndose el valor 4,12.

(5) Las ecuaciones y factores obtenidos en este trabajo no son muy diferentes a las relaciones que han sido determinadas por otros autores para especies similares.

(6) Ninguno de estos resultados debe ser tomado como definitivo. Sería conveniente en el futuro preparar experimentos apropiados para la obtención de una información que permita perfeccionar estas conclusiones.

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GENERAL REMARKS ON THE DESIGN, ANALYSIS AND EVALUATION OF FISHERY RESOURCE SURVEYS

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Abstract

To estimate the potential of a fishery, collation of several types of information is needed. These are: (i) size of the resource and its fluctuations; (ii) cost of fishing the resource and of subsequent marketing; and (iii) prediction of market demand conditions.

For an unexplored and unexploited fishery it is proposed that the survey be broken into two distinct phases: (i) exploratory fishing; and (ii) full-scale resource survey.

Idealization of surveys is discussed and methods of determining "surfaces of abundance" investigated.

Factors causing changes in distribution of areas of abundance and the relevance of these changes to survey design are also discussed. In the case of prawn resource surveys, these include: diurnal, within and between season variations; growth; migration; removal by fishing; and behaviour.

The need for comprehensive planning and strict adherence to the plan during the survey is stressed.

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OBSERVATIONS GENERALES SUR LE PLAN, L'ANALYSE ET L'EVALUATION DES ENQUETES SUR LES RESSOURCES MARINES

Résumé

L'évaluation du potentiel d'une pêcherie, exige l'exploitation de plusieurs types de renseignements, portant sur les points suivants : i) importance et fluctuations de la ressource; ii) coût de la pêche de cette ressource et de la commercialisation ultérieure; iii) prédiction des conditions de la demande commerciale.

Pour une pêcherie non prospectée et inexploitée, on propose de procéder à l'enquête en deux phases distinctes : i) pêche exploratrice; ii) enquête à grande échelle sur les ressources.

La communication traite de l'"idéalisation" des enquêtes, et étudie les méthodes servant à déterminer les "surfaces d'abondance".

Les auteurs examinent également les facteurs provoquant des modifications dans la répartition des zones d'abondance et l'importance que revêtent ces modifications pour l'établissement du plan d'enquête.

Enfin, la communication insiste sur la nécessité d'organiser le travail de façon approfondie et de respecter scrupuleusement le plan durant l'enquête.

OBSERVACIONES GENERALES SOBRE LA PREPARACION, ANALISIS Y EVALUACION DE LOS ESTUDIOS SOBRE LOS RECURSOS MARINOS

Extracto

Para calcular el potencial de una pesquería se necesita recoger varios tipos de información, a saber: (i) volumen del recurso y sus fluctuaciones; (ii) costo de la pesca del recurso y de su comercialización posterior y (iii) pronóstico sobre las condiciones de la demanda del mercado.

Para una pesquería sin explorar y sin explotar se propone que se distribuya el estudio en dos fases distintas: (i) pesca exploratoria y (ii) estudio del recurso a escala natural.

Se discute la idealización de los estudios y se investigan los métodos de determinar las "superficies de abundancia".

Se examinan igualmente los factores que ocasionan cambios en la distribución de las zonas de abundancia y la importancia que tienen estos cambios para la preparación del estudio.

Se insiste en la necesidad de realizar una planificación general y de seguir estrictamente el plan durante el estudio.

1 INTRODUCTION

To judge whether an area contains a potential fishery, several kinds of relevant information must be collated: firstly, the present size of the resource must be estimated: secondly, the costs involved in exploiting the resource and marketing the catch must be worked out, and, thirdly, the demand for the product must be forecast.

In this paper we shall be concerned only with estimating the distribution and current size of the resource. We shall discuss the shape of what we call the "surface of abundance", which is defined in greater detail below, but briefly denotes the spatial distribution of the resource. It is not proposed to discuss fully the practical details of a resource survey. Gulland (1962) has already given an excellent account of the sampling problems and techniques involved, and, although no attempt will be made to duplicate his work, it is inevitable that some of the same ground will be covered. The aim is simply to assist in the development of a set of concepts which may be useful to fisheries scientists engaged in planning resource surveys.

2 EXPLORATORY AND FULL-SCALE RESOURCE SURVEYS

Initially, information on an unexplored and unexploited resource is sought from published literature and other sources of information. The latter may be in the form of unpublished reports, casual observations or even verbal reports from fishing skippers or mariners. Answers to the following questions should be sought: What is known of the physical, chemical and biological characteristics of the proposed survey area? What commercially important species are likely to be present? What are the habitat preferences of these species? If answers to the above questions are found, then it is possible to predict which portions of the total area are most likely to sustain a fishery.

2.1 Exploratory surveys

Usually, as adequate biogeographical and environmental data are not available, exploratory fishing is necessary to make the above predictions and to determine whether a full-scale survey is warranted. During exploration data collected are not usually sufficiently detailed to estimate the absolute size of the resource. These will merely point to the presence of certain commercial species and give some indication of the extent of their habitat. Gear for exploratory fishing, and indeed for survey fishing generally, should be selected to make the most efficient use of sampling time rather than to take high catches. For example, in the search for potential prawn fisheries, try-nets are preferable to commercial nets as they are more easily shot and hauled. Sampling frequency is thus increased. The area to be explored should be selected so that it can be sampled adequately with the survey equipment available, thus ensuring that meaningful results are obtained and that sampling over a large range of habitat types can be carried out.

Under suitable conditions of supply and demand for the product, demonstration of the presence of the resource will often be sufficient to induce commercial fishermen to enter the area. On the other hand, the results of an exploratory survey may be insufficient to attract industry into a particular area. If the survey authority believes that a potential fishery exists and it is desirable that industry be induced to exploit the resource, a full-scale survey should be commenced.

2.2 Full-scale resource surveys

The purpose of the full-scale survey is to determine the extent of the grounds and the variations in fish density over the grounds at different times and circumstances. It is particularly important that uncalibrated gear should not be used during this phase of the survey and that the fishing power of the vessel should not change. If such changes occur, there is a tendency for these to be confounded with variations within the population, often making comparisons between times and areas erroneous. If it is considered essential that different gear be used, then the new gear should be calibrated against the known gear in properly designed trials.

Careful planning is essential to achieve maximum efficiency. It is necessary to consider the following questions prior to detailed planning: How much work can be expected from available vessels, gear and staff? What is the variability of results from the sampling technique to be used, e.g., trawl-nets, longlines, traps, etc.? What data are to be collected and which design is most suitable for recording sheets? If computer analysis is anticipated, then sheets should be designed to simplify preparation of data for presentation to the computer.

An integral part of a resource survey is the collection of biological and environmental information during fishing. This assists in assessing the potential of the fishery and makes the current survey more efficient. Before deciding what information is to be collected, we must consider what biological or environmental questions require answers. Such questions may include: When and where are the fish at the most preferred size for marketing? Are there any parasites present that may cause market resistance? If the fish are migratory, what are the seasons of occurrence in the survey area and what is the path and rate of migration from the area? How does the occurrence or vulnerability of the fish vary with changes in the physical, chemical or biological environment?

Extreme caution should be exercised in the collection of data that is 'interesting' or 'may be useful later'. These data are often left unused until they become outdated.

At best, surveys measure only the standing crop, and are not sufficiently comprehensive to make predictions of the dynamic response of the population to fishing. Nevertheless, collection of data required for the estimation of sustainable yield should be commenced at this stage and continued from commercial fishing units as these commence operations.

3 IDEALIZATION OF SURVEY

In this section we shall use an idealized survey to establish terminology and to set up criteria for designing, analyzing and evaluating resource surveys. We shall assume that the unknown distribution of the resource could be represented approximately by a smooth 'surface of abundance' (Fig.1). We assume that the aim of the survey is to estimate the shape of this surface by sampling over some grid of points superimposed on the space occupied by the resource. To make the model more realistic, we shall also assume that there are small-scale variations of density throughout the surface of abundance and that our sampling instrument will make errors of measurement which we cannot distinguish from such deviations in density.

If we first set up our grid over the whole space without reference to any prior knowledge of the distribution of the resource, we shall, in principle, be able to form an unbiased picture of the whole surface. Moreover, if the number of sample points is large enough to cope with deviations and error of measurement we shall form an accurate picture. Without going into the technicalities of procedure, we would construct this picture by using some objective method of surface fitting such as the method of fitting polynomials by least squares or by manual contouring methods. Computation of relative abundance would be consistent with the contouring procedure and derived by estimating the 'volume' of resource lying below the surface.

At the present level of technology, it is usually not possible to state precisely the area of effect (swept area) of a single operation of the particular sampling or fishing gear being used, nor is it possible to say exactly what proportion of animals within the area of effect are enumerated or removed by each operation of the gear. It is usually assumed that the swept area of a unit operation is constant and that the

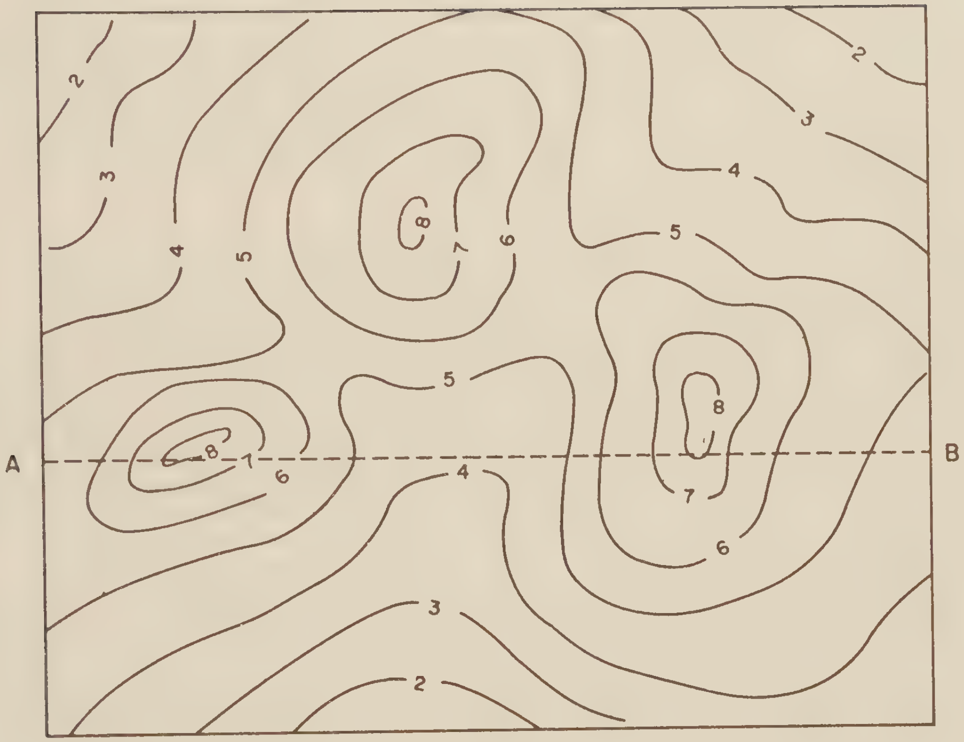

Fig. 1 Contoured representation of a hypothetical surface of abundance of a resource.

proportion of animals captured with it is also constant. If these assumptions are nearly true then the sampling procedure and method of surface fitting will yield a close approximation to the shape of the surface of abundance. Contours of abundance at different points in the space will then give relative measures of abundance. It is necessary to calibrate the sampling gear in some way to convert these to absolute measures. This conversion is far from simple, and may be complicated by variations in the behaviour of the fish in relation to the gear, so that the catch per unit of effort does not bear a constant relation to absolute abundance.

A multi-phase strategy is frequently the most efficient. We use a two-phase version of our idealized survey to illustrate this concept. Suppose that in the first phase our grid of sample points is uniformly spread over the whole space. In addition to recording the count or weight of animals, we record also a number of other characteristics at each point. It may then be possible to draw contours describing the distribution of these other variables. As a simple example, we may find from the first phase that the type of bottom may be classified broadly into two types and that the density of fish is relatively high on type A and low on type B. We may then decide that in the second phase we shall sample more intensively over areas of type A to chart more accurately the abundance of animals there.

The above procedure may be contrasted with that of a commercial fisherman just starting to trawl a new ground. His strategy might be as follows. He first makes a trawl shot completely at random. If this yields good results he marks the area with a buoy and fishes around it till the catches fall. If the first shot is unsatisfactory he moves some distance away and trawls again. We may analyze the characteristics of such an operation with the aid of idealized resources. We first plot the assumed distribution of resource (Fig. 2) along the section AB from Fig. 1. We postulate that the deviations from the surface tend to be such that if we sample at two closely spaced points the deviations will be similar but that as the points are more widely-spaced the correlation diminishes. Our sampling strategy described earlier leads us to take samples at points x_o, x_1, x_2, etc., at which spacings the correlation between deviations is negligible and we form a good picture of the shape of the surface along AB. The result of the fisherman's strategy (Fig. 3) may be shown in an enlarged view of section x_2 to x_5 of Fig. 2, illustrating the postulate about deviations from the surface stated above. Suppose the fisherman trawls at one of the points corresponding to the set of small circles and decides that the catch is too low. He moves on and by chance reaches a position corresponding to one of the set of crosses. He may then make several shots until the catch rate falls. Thus he will tend to make several shots wherever he finds a high level of abundance and only one at low levels. This point is of great importance when one is comparing catch rates of a survey vessel fishing on a preselected grid of points and a fishing vessel following the strategy just described. It is to be expected that a fisherman's overall catch rate will always be higher than that of a survey vessel.

The survey method described yields an estimate of relative abundance over the whole space, but it is virtually impossible to do this from a fisherman's results. This is not a condemnation of fishermen's methods, of course, but is mentioned merely to illustrate the different results which should be inferred by studying two sets of data.

Having established the broad shape of the surface of abundance, it may then be thought desirable to induce fishermen to enter the survey area by obtaining maximum survey vessel catches using fishermen's methods. It is important when studying these latter data to know the strategy of operations which produced them. Alternatively, it may be useful to employ a 'mixed strategy' of surveying, i.e., the survey vessel follows a systematic grid of stations, but, if a good catch is observed at any station, a number of follow-up shots are made at that spot before the unit moves to the next station.

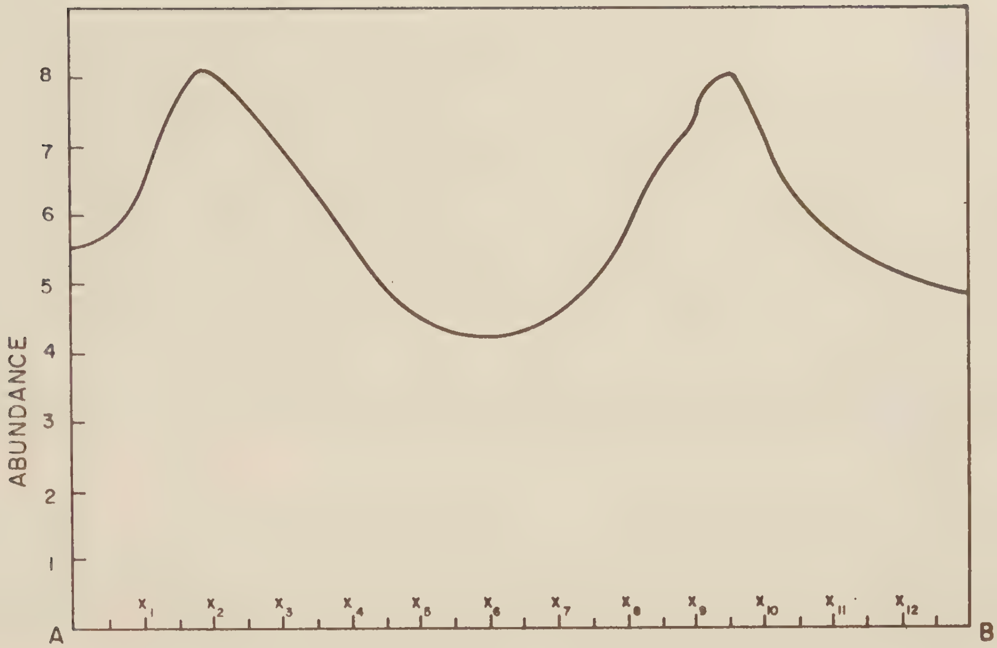

Fig. 2 Profile of surface of abundance along section AB of Fig. 1.

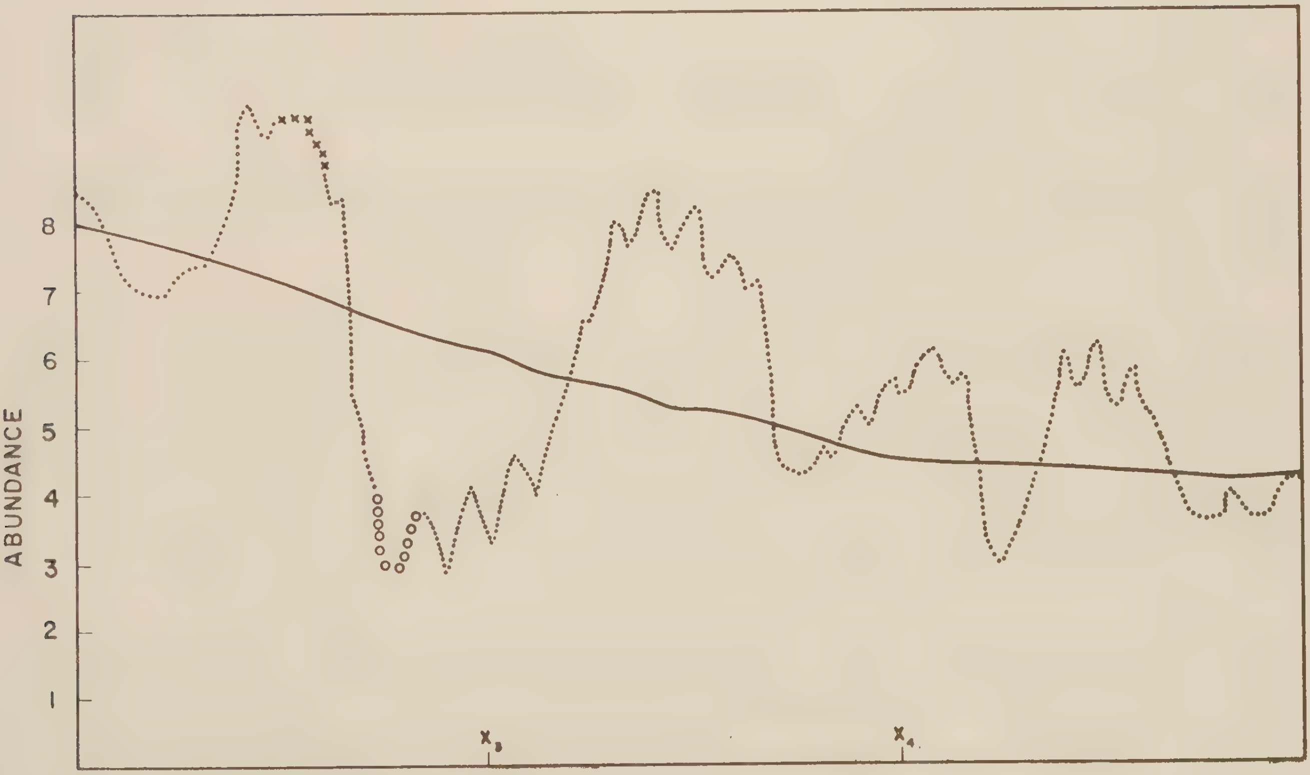

Fig. 3 An enlarged view of segment x_2, x_5 of Fig. 2.

4 CHANGES IN THE DISTRIBUTION OF ABUNDANCE AND THEIR RELEVANCE TO SURVEY DESIGN

In general, the surface of relative abundance of a resource will change in shape and absolute size from one instant of time to the next. It may, for example, have a slow long-term trend, underlying periodic fluctuations of varying frequencies, phases and amplitudes. A trend may be associated, for example, with slow environmental changes such as progressive pollution. Periodic fluctuations may relate to annual cycles of reproduction, growth, migration, etc. Apparent periodic fluctuations may be due to varying responses of the population, or some members of it, to the operations of the fishing unit, so that while the actual size and distribution of the population remain constant, they may appear to change. The surveying equipment may also be subject to outside influences, e.g., rough weather may affect fishing efficiency.

To illustrate the way in which several types of biological and behavioral factors affect the distribution of abundance (or apparent abundance) we can examine the results of various research programs in Shark Bay (Slack-Smith, in press; Slack-Smith and Stark, in press).

A factorial trawling experiment was carried out to examine the variability of trawling results in a restricted area. Lunar and diurnal changes were the variates considered. Four daily periods and four lunar periods were used on four adjacent randomized blocks. It was observed that catches of both king prawns (Penaeus latisulcatus Kishinouye) and tiger prawns (P. esculentus Haswell) were significantly greater during the hours of darkness and at the time of the new moon. It is unlikely that changes in actual abundance occurred, but probably that these variations were due to catchability changes. This indicates that before any meaningful comparisons could be made between trawling results from different areas, these cyclic variations must be eliminated.

Violent annual fluctuations in penaeid recruitment are well known, and these, as well as variations of time of recruitment within the year, must also be considered when a trawling survey is being planned or the results analyzed.

Further sources of variation to be considered include the rapid growth and high mobility of these animals. Both affect the distribution and abundance of prawns quite markedly. Every endeavor should be made to account for all such sources of variation when surveys are being planned.

What has been written perhaps adds weight to what is already well-known: that the planning of an effective resource survey is a very complex operation. It is therefore worthwhile to see whether there exists any established body of methodology which would aid planning, even if only with respect to general principles rather than to details. We believe that some of the methods devised for studying response surfaces and the general theory of statistical designs underlying these methods are relevant. An account of these techniques can be found in Davies (1954). Clearly, the situations for which these methods were developed are much simpler than those facing the scientist who is charting wild populations, but the concepts are valuable. A brief outline of response surface concepts will show the similarities.

Much of the work on response surfaces has been done in connection with problems arising in the chemical industry, where manufacturers have wanted to find, for example, the levels of several imput factors which will produce the optimum yield of a product. It is postulated that the yield or response is a function of several quantitive factors. A typical example of such a yield surface is shown in Fig. 4 and represented by contours in Fig. 5. An obvious method of finding the shape of this surface would be to make observations corresponding to a grid of points spread over the time-concentration space. A contour surface in a three-dimensional factor space is shown in Fig. 6. Its shape also could be studied by taking observations over a grid of points in the whole factor space.

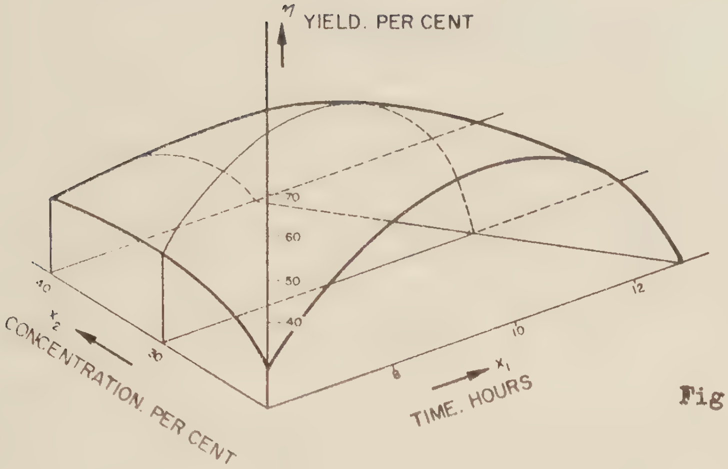

Fig. 4 A typical yield surface (after Davies, 1954).

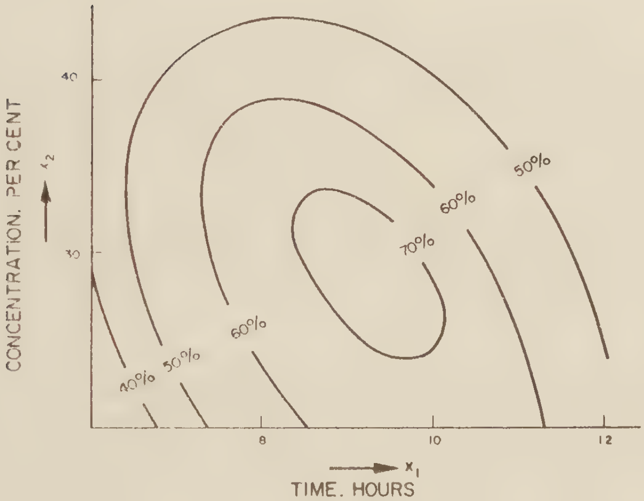

Fig. 5 Yield contours for surface shown in Fig. 4 (after Davies, 1954).

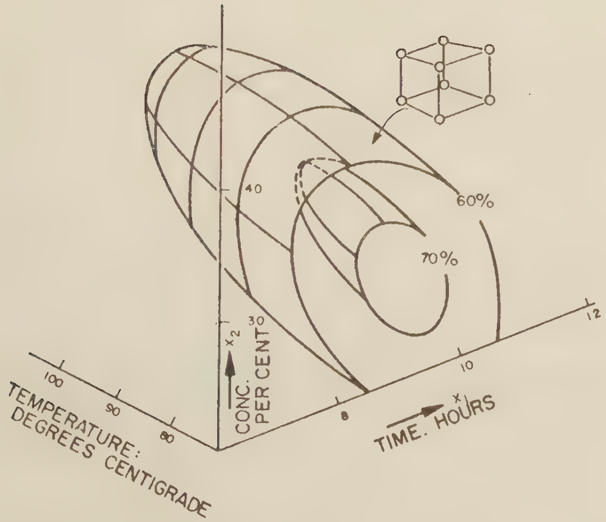

Fig. 6 Contour surfaces in a 3-dimensional factor space with a 2^3 factorial design (after Davies, 1954).

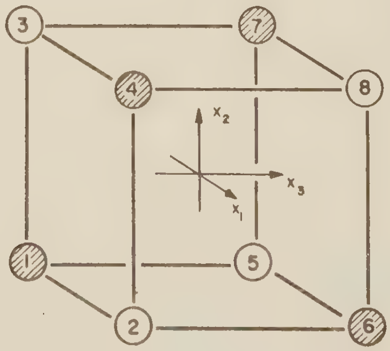

Fig. 7 A 2^3 factorial design showing the division into half-replicate designs (after Davies, 1954).

The similarity between a surface of abundance (our earlier idealization) and yield or response surfaces, will now be apparent. The population density of animals corresponds with yield, and the spatial, time and biological variables correspond with the factors determining yield. In most response surface studies, the object is to locate the co-ordinates of the maximum of the surface rather than to chart the whole surface. Thus the two contrasting aims correspond respectively with those of the fisherman and the scientist charting the surface of abundance. Nevertheless some of the concepts for determining the maximum of the response surface, in particular the use of fractional factorial experimentation, are useful for the wider problem of charting the shape of the whole space. Davies (1954: 507) shows how a two-level fractional factorial design can be used to find the slope of the surface over a small region of the factor space. The cube of points is shown in miniature in Fig. 6, and in detail in Fig. 7. This gives the two possible experimental designs. The point of interest here is that it is not necessary to carry out the full factorial array of observations to give the required answer.

We do not pretend that survey planning can be simplified to the extent suggested by this discussion, but we do suggest that survey efficiency would be greatly enhanced if an attempt were made to incorporate some of these concepts.

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Mr. A.J. Fraser, Dr. R.G. Chittleborough and Mr. B.K. Bowen read the manuscript and Mrs. E.H. Barker prepared the figures.

PRESENCIA DE ALGUNOS ESTADIOS LARVALES DE PENEIDOS EN UN AREA CAMARONERA AL SUR DE CUBA

por

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Extracto

Con el fin de conocer la morfología de las larvas del camarón comercial Penaeus schmitti Burkenroad y sus diferencias con las de Penaeus duorarum, se realizó un muestreo de plancton en Tunas de Zaza, un área camaronera al sur de Cuba, donde existe un predominio de P. schmitti, encontrándose hembras próximas a desovar. Se aplica el plan de trabajo y métodos empleados y se describen las nuevas larvas encontradas. Se discute la posibilidad de que las larvas descritas pertenenzan a P. schmitti o al género Sicyonia. Se hacen sugerencias para futuros trabajos.

PRESENCE OF CERTAIN PENAEID LARVAL STAGES IN A SHRIMPING AREA SOUTH OF CUBA

Abstract

With a view to studying the morphology of the larvae of the commercial shrimp species Penaeus schmitti Burkenroad and differentiating it from the pink shrimp, P. duorarum, a plankton sampling was made at Tunas de Zaza, a shrimping area south of Cuba, where P. schmitti predominates and females ready to cast their eggs were found. The plan of work and methods used are described as are also the young shrimp caught. There follows a discussion of whether the larvae described belong to the P. schmitti or the Sicyonia genus. Suggestions for future work are profferred.

E/28

PRESENCE DE QUELQUES STADES LARVAIRES DE PENEIDES DANS UNE ZONE A CREVETTES AU SUD DE CUBA

Résumé

Pour étudier la morphologie des larves de la crevette Penaeus schmitti Burkenroad, présentant un intérêt commercial, et la comparer avec Penaeus duorarum, on a procédé à des prélèvements d'échantillons de plancton à Tunas de Zaza, zone à crevettes située au sud de Cuba où prédomine P. schmitti et où l'on a rencontré des femelles prêtes à pondre. L'auteur décrit le plan de travail et les méthodes employées, ainsi que les nouvelles larves rencontrées. Il examine la question de savoir si les larves décrites appartiennent au genre P. schmitti ou au genre Sicyonia. Quelques propositions sont avancées pour les activités futures.

1 INTRODUCCION

Los camarones son una parte muy importante en las pesquerías cubanas, pues desde hace muchos años se realiza una captura considerable de los mismos en las zonas de plataforma que rodean la Isla de Cuba.

Es sabido que los camarones poseen características biológicas complejas y que su estudio plantea problemas de muy diversa índole. Entre esos problemas, las migraciones de los adultos y la determinación de los lugares de desove y de cría, están relacionados con el estudio de las larvas de camarones.

En Cuba se ha registrado la presencia de más de diez especies diferentes de camarones, aunque de ellas solamente tienen importancia comercial el camarón acaramelado, *Penaeus duorarum* Burkenroad, 1939 y el camarón blanco, *Penaeus schmitti*, Burkenroad 1936. La captura de dichas especies se realiza casi exclusivamente en la plataforma sudoriental de Cuba, que se extiende desde Cienfuegos hasta Cabo Cruz. Según un muestreo, la composición por especies da un 66% de *P. duorarum* y un 34% de *P. schmitti*.

Los estadios larvales de *P. duorarum* a partir del huevo, los nauplios, protozoeas, mysis y post-larvas, son bien conocidos después del excelente trabajo realizado por Dobkin (1961) en aguas de la Florida. Hasta donde alcanzan nuestros conocimientos, los estadios larvales de *P. schmitti* no están descritos todavía. Por lo tanto, en Cuba, la investigación de la biología pesquera de los camarones debe basarse, principalmente en un estudio de los estadios larvales de *P. schmitti* para conocer su morfología, y establecer la diferenciación de las especies durante su período larval. Por esa razón, el Centro de Investigaciones Pesqueras, del Instituto Nacional de la Pesca, ha dedicado especial atención a dicho estudio.

Los objetivos de la investigación sobre larvas de camarones han sido los siguientes:

a) describir los estadios planctónicos de *P. schmitti*;

b) señalar las principales diferencias entre los distintos estadios larvales de las dos especies comerciales cubanas.

El presente informe se elabora con los resultados obtenidos hasta ahora, ya que los trabajos continúan realizándose.

Deseamos agradecer a Miroslav Nikolić, biólogo pesquero de la FAO en Cuba, su constante apoyo y sugerencias en el desarrollo de este trabajo. También a Nancy Aguiar por la ayuda prestada en el laboratorio.

2 PLAN DE TRABAJO

El modo más seguro para conocer los estadios larvales de una especie consiste en la cría de la misma desde el huevo en condiciones controladas de laboratorio, pero dicho método no nos ha sido posible seguirlo hasta el presente. No obstante, y teniendo en cuenta que las poblaciones de las dos especies comerciales cubanas de camarones se encuentran mezcladas, hemos tomado muestras de plancton de las áreas de pesca, basándonos en el siguiente plan de trabajo:

a) si existen especies cuyos adultos son predominantes en una región, y se encuentran en período de desove, sus larvas deben encontrarse en abundancia;

b) si al tomar una muestra de plancton en un área con las dos especies predominantes, las larvas de camarones encontradas coinciden morfológicamente con la descripción de Dobkin, se trata de larvas de P. duorarum;

c) si encontramos larvas que no coinciden con la descripción de Dobkin, y que a su vez son abundantes, podemos suponer con mucha probabilidad que se trata de larvas de P. schmitti, las cuales intentamos describir.

En el muestreo de la zona estudiada hemos encontrado dos tipo de larvas de camarones abundantes:

a) un tipo que concuerda con la descripción de Dobkin en casi todos sus detalles, aunque de tamaño algo menor. Se trata de larvas de P. duorarum;

b) un tipo que no concuerda con la descripción de Dobkin, que es tan abundante como el tipo anterior y que forma una serie lógica en la sucesión de los estadios.

3 MATERIALES Y METODOS

El material para este trabajo consiste en 28 muestras de plancton recogidas a bordo del barco "Camarón" que se dedica a la pesca de arrastre en el plan de investigación de los camarones realizado por el Centro de Investigaciones Pesqueras. El viaje se efectuó del 14 al 23 de septiembre de 1966, en áreas cercanas a la costa de Tunas de Zaza, al sur de Cuba, una región de pesca tradicional de camarón blanco, cuyos sedimentos superficiales del fondo están formados por fango gris.

Se tomaron muestras horizontales de plancton en dos secciones que se extienden desde la costa hasta cuatro millas de distancia de la misma. La primera sección se hizo partiendo de la desembocadura del río Zaza, y la segunda en la Ensenada de Guayacanes. En las doce estaciones realizadas se recogió plancton en la superficie y a una profundidad que oscila entre 2 y 10 m. La red de plancton utilizada tenía 30 cm de diámetro en la boca y una tela filtrante de seda de 0,31 mm de abertura de malla. Al no utilizarse una red de cierre, la muestra horizontal subsuperficial tiene una pequeña mezcla con las aguas superficiales en el momento de su recogida. Todos los muestreos fueron de 1 minuto de duración y la velocidad del barco era de 1,8 m/seg.

A la par que los muestreos de plancton, se realizaron capturas por arrastres en las mismas estaciones. Utilizando una red tipo americano semibalón de 375 y otra tipo japonés de 350 mallas, se pescó durante 75 horas de trabajo en 10 arrastres diurnos y 24 nocturnos, capturando un total de 1.400 kg de camarones. De esa captura se hicieron 8 estudios biométricos tomando muestras al azar, analizándose en total 803 camarones, de los cuales el 95% pertenecía a la especie de P. schmitti y el 5% restante a P. duorarum. De las 379 hembras de P. schmitti, el 5,8% (22 ejemplares) estaban impregnadas.

En el laboratorio, las larvas conservadas en formol al 2%, se separaron de las muestras y se estudiaron. Al hacer las descripciones se han tomado en consideración solamente los caracteres más notables. Los dibujos han sido realizados en cámara clara y esquematizados. Al lado de cada esquema aparece una recta dividida en 0,1 mm a escala con el dibujo. Algunas setas se suprimen y en las setas plumosas los cilios no se dibujan en su totalidad para no oscurecer el esquema.

4 DESCRIPCION DE LAS LARVAS

4.1 Primera protozoea

En las larvas que corresponden a este estadio no se han encontrado ejemplares que difieran de la descripción dada por Dobkin para P. duorarum.

4.2 Segunda protozoea

Se examinaron 12 larvas de segunda protozoea (Fig. 1). En el estadio protozoea las larvas fueron medidas desde el borde anterior del carapacho hasta el borde posterior de las ramas furcales para hacer comparable la longitud de este estadio con la del mysis. El largo de la segunda protozoea oscila entre 1,1 y 1,3 mm.

En este estadio los ojos ya formados aparecen fuera del carapacho, el abdomen se segmenta y aparece el rostro.

El carapacho es pequeño, bastante ajustado al cuerpo del animal, está algo levantado, y no cubre ningún segmento torácico. El carapacho tiene una longitud equivalente a la tercera parte de la longitud del animal. El rostro que aparece por primera vez en este estadio, es corto y está algo curvado ventralmente. La longitud del rostro es de un décimo de la longitud del carapacho aproximadamente. Las porciones laterales del borde posterior del carapacho están algo extendidas hacia atrás.

Los segmentos torácicos son seis, al igual que los segmentos del abdomen. El sexto segmento abdominal es más largo que los primeros cinco. Estos cinco primeros segmentos abdominales son ligeramente mayores que los torácicos y no presentan espinas en su parte dorsal.

No existe división entre el sexto segmento abdominal y la porción posterior del animal. Esta última porción está dividida en dos ramas furcales, cada una de las cuales tiene siete espinas. Seis de ésas son setosas y terminales y la séptima es lisa y dorsal.

Los ojos formados son pedunculados en este estadio y se proyectan hacia afuera, libres del carapacho.

La primera antena está formada por tres porciones, de las cuales la basal está segmentada a su vez en 5 partes. La segunda antena consta de un protopodio, un exopodio y un endopodio.

Los pereiópodos aparecen en este estadio como botones muy rudimentarios. No existen pleópodos ni urópodos.

Las principales diferencias entre la especie P. duorarum y las larvas encontradas en este estadio son las siguientes:

a) en P. duorarum el carapacho es ancho y llega hasta el tercer segmento torácico, mientras que en las larvas encontradas el carapacho es estrecho y no cubre ningún segmento torácico;

b) el rostro es largo en P. duorarum y corto en las larvas encontradas;

c) en las larvas encontradas no existen espinas supraorbitales, mientras que en P. duorarum son evidentes y bifurcadas.

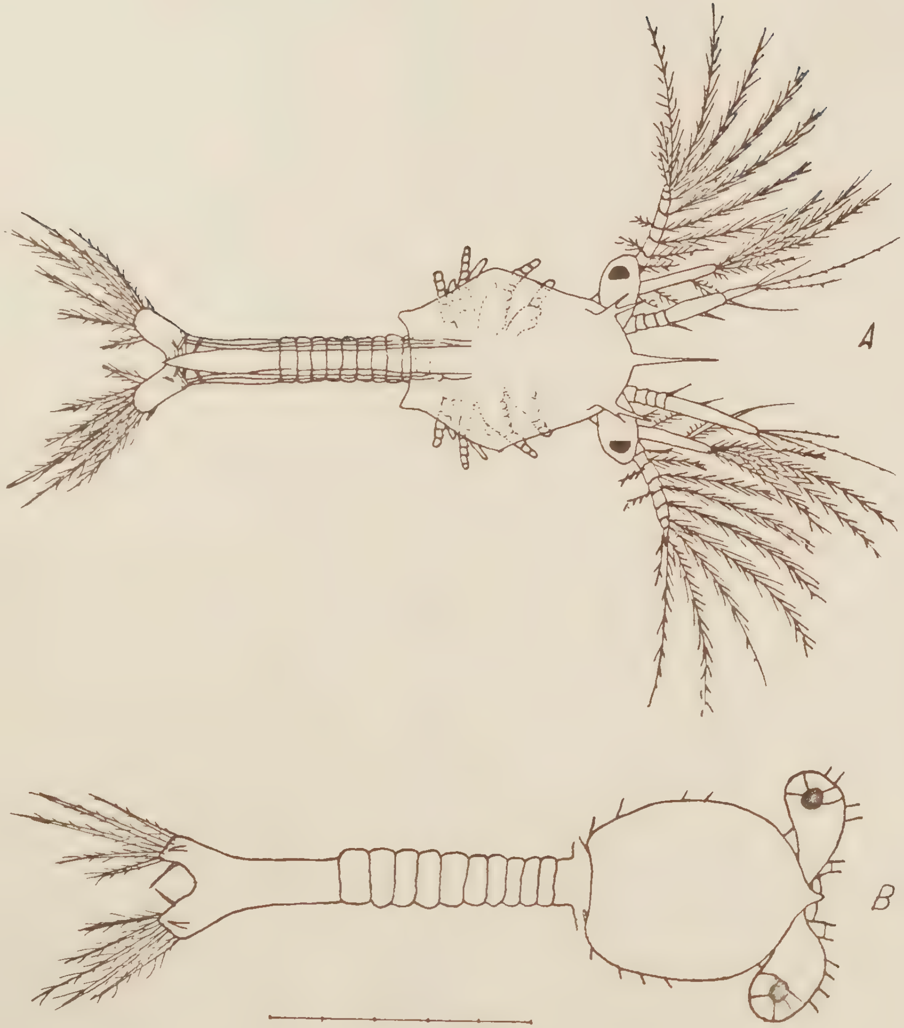

Fig. 1 Segunda protozoea, vista dorsal:
A) P. duorarum (según Dobkin)
B) larvas encontradas.

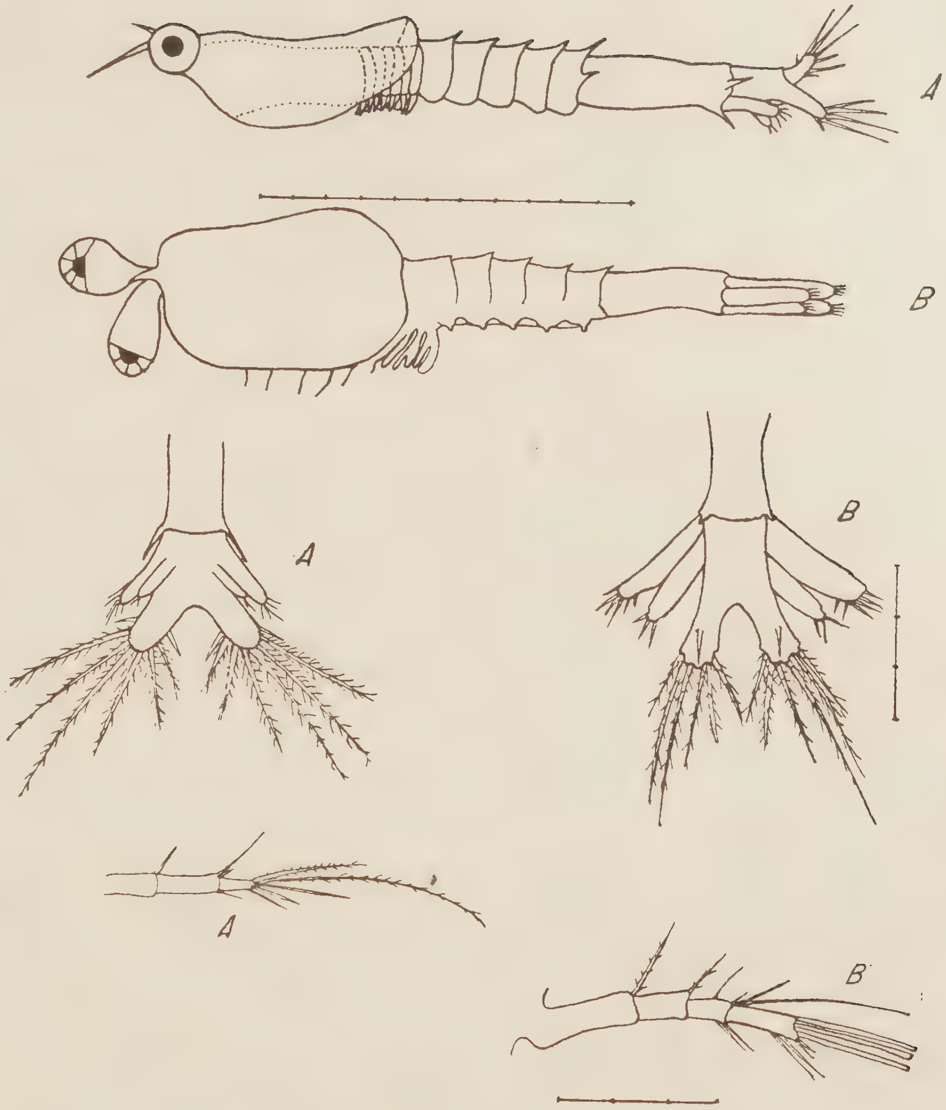

Fig. 2 Tercera protozoea, vista lateral, rama furcal, primera antena:
A) P. duorarum (según Dobkin)
B) larvas encontradas.

4.3 Tercera protozoea

Se examinaron 32 larvas en el estadio de tercera protozoea (Fig. 2). La longitud total de las mismas oscila entre 1,4 y 1,9 mm.

Este estadio se diferencia del anterior principalmente por la aparición de los urópodos y las espinas del borde superior de los segmentos abdominales.

Visto desde arriba el carapacho alcanza el primer segmento torácico, y tiene dos expansiones laterales que se extienden hacia atrás, hasta el tercer segmento torácico. El rostro está presente, pero no se observan espinas supraorbitales.

Los segmentos torácicos son estrechos, mientras que los abdominales están mucho más desarrollados. Los cinco primero segmentos abdominales son de tamaño similar, pero el sexto segmento está muy desarrollado, siendo su longitud igual a la de los cuatro segmentos precedentes unidos. Existen espinas dorsomedianas en el borde posterior de los cinco primeros segmentos abdominales, pero no son muy pronunciadas. El segmento abdominal quinto posee un par de espinas posterolaterales. Además, el borde inferior de las pleuras de los cinco primeros segmentos abdominales se prolonga en una expansión terminada en punta, carácter que en este estadio no está muy desarrollado. El sexto segmento abdominal está separado del telson, es alargado, y lleva en su borde posterior un par de espinas posterolaterales situadas encima de la inserción de los urópodos y un par de espinas posteroventrales situadas debajo de la inserción de los urópodos. Todas las espinas del abdomen están dirigidas hacia atrás.

Cada rama furcal posee siete espinas, de las cuales una es dorsal y pequeña; otra es lateral, mediana y se cruza en la línea media con la del lado opuesto; y las otras cinco son grandes y terminales (Fig. 2).

Las primeras antenas (Fig. 2) son unirramosas, están dirigidas hacia delante y están formadas por cuatro segmentos. El primer segmento tiene una seta larga en su extremo distal, y el segundo lleva una seta mediana en su extremo distal. El tercer segmento tiene una seta mediana en su borde interno, dos setas en su extremo externo y tres setas en su extremo interno, de las cuales una es de gran dimensión. El segmento distal tiene dos setas en su borde externo y cinco setas en su extremo. Hay un total de quince setas en la primera antena. Las segundas antenas son birramosas y coinciden en sus detalles con la descripción de Dobkin.

Los pereiópodos son birramosos y rudimentarios. Los pleópodos no están desarrollados. Los urópodos se forman a nivel del extremo posterior del sexto segmento abdominal. Están formados por dos ramas, de las cuales la externa es mayor y tiene seis setas terminales, y la interna tiene tres setas terminales.

En el estadio de tercera protozoea las larvas encontradas se diferencian de la especie P. duorarum por los siguientes caracteres:

a) P. duorarum no posee expansiones en bordo inferior de la pleura de los cinco primeros segmentos abdominales, mientras que las larvas encontradas sí las presentan;

b) las larvas encontradas tienen siete espinas en las ramas furcales y P. duorarum tiene ocho;

c) P. duorarum tiene tres segmentos en la primera antena, mientras que las larvas encontradas tienen cuatro.

4.4 Primera mysis

Se examinaron 22 larvas en el estadio de primera mysis (Fig. 3). La longitud total oscila entre 1,9 y 2,2 mm. En el estadio mysis la longitud de las larvas se midió desde el borde anterior del carapacho hasta el borde posterior del telson.

El estadio de primera mysis se diferencia mucho del de tercera protozoea anterior. Se caracteriza por su aspecto, más parecido a un camarón, por el desarrollo de los apéndices torácicos, la morfología de las primeras y segundas antenas, el desarrollo de los urópodos y la formación del telson.

El carapacho no cubre el tórax. Tiene expansiones laterales en el borde posterior y se encuentra algo levantado. El rostro está proyectado en línea recta hacia delante y presenta una espina hacia la base. Se observan espinas supraorbitales cortas y un par de espinas en la esquina anterolateral del carapacho.

Los cinco primeros segmentos abdominales son de tamaño menor que el sexto. Estos segmentos tienen espinas dorsomedianas muy reducidas o desaparecidas, mientras que hacia hacia la cara ventral se observa el margen puntiagudo de las pleuras abdominales que están expandidas. El sexto segmento abdominal presenta una espina dorsomediana en su borde posterior, pero no presenta espinas ni por encima ni por debajo de la inserción de los urópodos. El quinto segmento abdominal no presenta espinas posterolaterales.

En este estadio se ha producido el acercamiento y fusión de las ramas furcales y el telson se presenta como un apéndice único en el extremo posterior de la larva (Fig. 3). La hendidura que se encuentra en la línea media es profunda. El punto más profundo de la hendidura está situado a nivel de la región entre la espina lateral y la espina terminal mas externa. El telson presenta seis pares de espinas terminales y un par de espinas laterales.

La primera antena (Fig. 3) está transformada. Consta de tres segmentos, siendo el primero tan largo como los otros dos unidos. El extremo distal presenta dos ramas, de las cuales la externa tiene doble longitud que la interna. El segmento basal presenta dos espinas, una corta en su base y la otra larga en la unión del tercio medio con el tercio distal. Los bordes y extremos de los segmentos de la primera antena tienen varias setas plumosas.

Los pereiópodos son birramosos y en este estadio alcanzan mayor tamaño. Los pleópodos no están desarrollados. Los urópodos están a ambos lados del telson. Consta de un protopodio, del cual salen el exopodio ancho y el endopodio estrecho, ambos de igual longitud.

En el estadio de primera mysis las larvas encontradas difieren de las de la especie P. duorarum en los siguientes caracteres:

a) las larvas encontradas presentan una espina a nivel del rostro, mientras que en P. duorarum el rostro es liso;

b) las larvas encontradas tienen bien desarrolladas las expansiones del borde ventral de las pleuras de los cinco primeros segmentos abdominales, mientras que P. duorarum no tiene esas expansiones;

c) en el telson, las larvas encontradas tienen seis espinas terminales y una lateral, mientras que P. duorarum tiene siete espinas terminales y una lateral;

d) en el segmento basal de la primera antena las larvas encontradas presentan dos espinas, mientras que P. duorarum solamente presenta una.

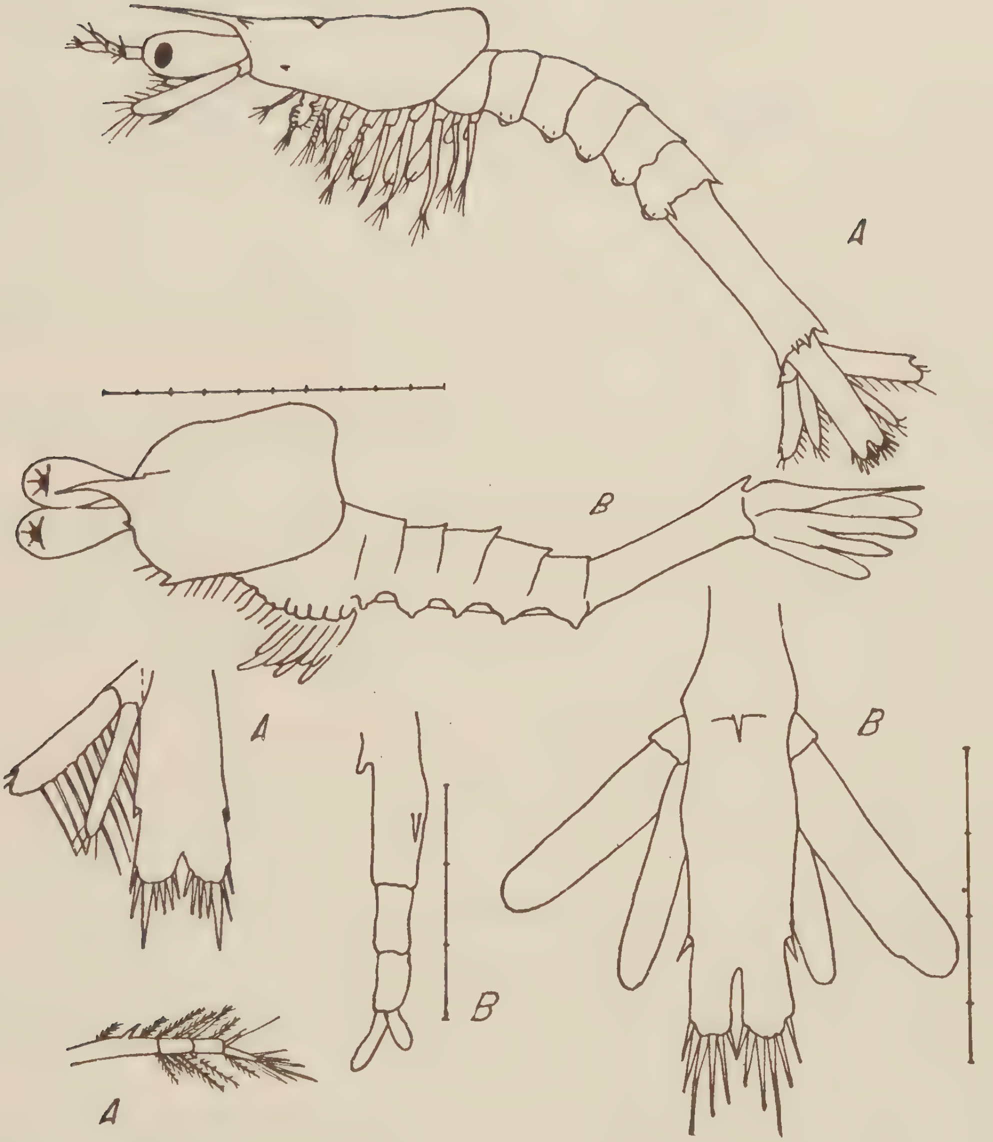

Fig. 3 Primera mysis, vista lateral, telson, primera antena:
A) *P. duorarum* (según Dobkin)
B) larvas encontradas.

4.5 Segunda mysis

Se analizaron 16 larvas en estadio de segunda mysis (Fig. 4). La longitud total oscila entre 2,1 y 2,4 mm.

Este estadio se diferencia del anterior por la menor profundidad de la hendidura del telson, la aparición de los pleópodos, el aumento de una espina detrás del rostro, y los estatocistos situados en la base de la primera antena.

El carapacho cubre escasamente los primeros segmentos del tórax, aunque sus expansiones laterales alcanzan hasta el cuarto o quinto segmento torácico. El rostro se extiende hacia delante en línea recta y en este estadio se encuentran dos espinas pequeñas en la carina detrás del rostro. Las espinas supraorbitales son cortas y las anterolaterales pronunciadas. Entre ambas existe una expansión terminada en punta que corresponde a las espinas suborbitales.

En el abdomen es notable el desarrollo de los márgenes ventrales de las pleuras de los cinco segmentos, las cuales terminan en punta. Las espinas dorsomedianas están reducidas o desaparecidas, menos la del sexto segmento que es bien visible.

El telson (Fig. 4) tiene forma rectangular y en su borde posterior la hendidura es pequeña. Existen 6 espinas terminales y 1 espina lateral a cada lado. El punto más profundo de la hendidura se encuentra a nivel de la espina más externa.

La primera antena (Fig. 4) tiene tres segmentos; el segmento basal presenta el estatocisto y dos espinas. La rama externa del último segmento es de doble longitud que la rama interna. En esta antena hay varias setas plumosas.

La segunda antena consta de un protopodio provisto de una espina, un exopodio con una espina subterminal y un endopodio parecido a una varilla puntiaguda. El endopodio tiene una longitud de las tres cuartas partes del exopodio.

Los pereiópodos son birramosos y mayores en este estadio. Los pleópodos aparecen entre las expansiones de las pleuras abdominales como botones redondeados.

Las larvas encontradas y las de P. duorarum se diferencian en el estadio de segunda mysis por los siguientes caracteres:

a) las larvas encontradas presentan dos espinas a nivel del rostro, mientras que P. duorarum tiene un rostro liso;

b) los bordes laterales de las cinco primeras pleuras abdominales son muy pronunciados en las larvas encontradas, mientras que en P. duorarum no se observan esas expansiones;

c) el telson presenta 6 espinas terminales y 1 espina lateral en las larvas encontradas, mientras que en P. duorarum presenta 7 espinas terminales y 1 espina lateral;

d) la primera antena de las larvas encontradas tiene dos espinas en el segmento basal, mientras que en P. duorarum solamente presentan una. Además, las dos ramas del segmento distal son casi iguales en P. duorarum, mientras que en las larvas encontradas son de diferente longitud.

5 DISCUSION

Los estadios larvales de camarones descritos previamente constituyen una serie lógica de acuerdo con las transformaciones que aparecen en su morfología. Queda por dilucidar si dicha serie corresponde a la especie P. schmitti o se trata de otra especie.

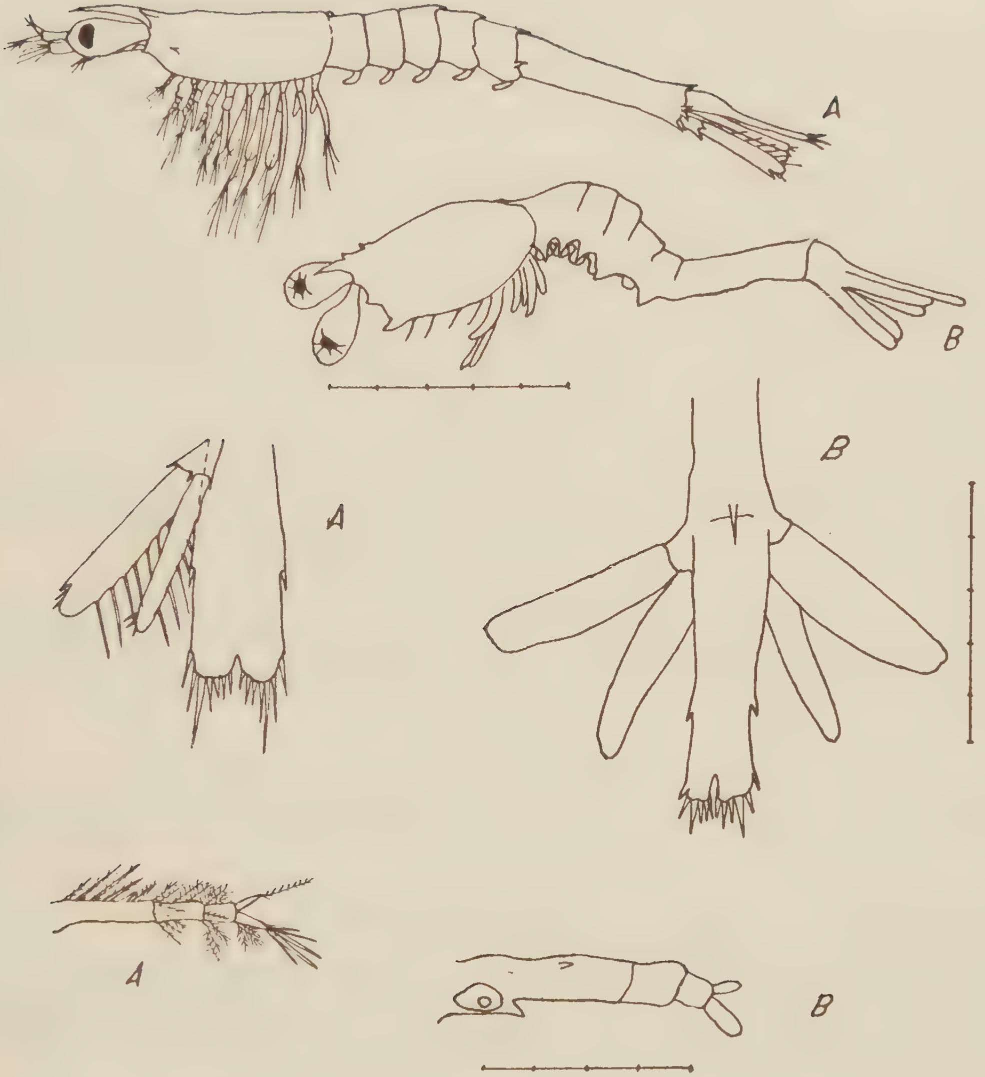

Fig. 4 Segunda mysis, vista lateral, telson, primera antena .
A) P. duorarum (según Dobkin)
B) larvas encontradas.

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Pearson (1939) captura huevos en el plancton de las aguas de Florida y los cría en acuarios, obtenidendo una serie de nauplios, protozoeas y mysis, cuya morfología tiene un gran parecido con las larvas descritas en este trabajo. Sobre todo es significativo el parecido de las márgenes ventrales de las pleuras de los cinco primeros segmentos abdominales. Este autor atribuye dichos huevos a la especie Eusicyonia stimpson (Bouvier). En la subfamilia Sicyoninae se han registrado en Cuba las especies Sicyonia typica (Boeck) y Sicyonia brevirostris Stimpson (Pérez Farfante, 1954). Ambas especies tienen el exoesqueleto duro y son de menor tamaño que los camarones comerciales. Estas especies de camarones son conocidos vulgarmente como camarón reyecito y se encuentra en muy escasa cantidad en las zonas de camarón comercial. En la captura realizada durante el viaje de estudio a Tunas de Zaza no se observó en ninguna ocasión.

¿Pueden tratarse de larvas del género Sicyonia las descritas en este trabajo? Si bien nos inclinamos a pensar que las larvas encontradas pertenecen a la especie P. schmitti teniendo en cuenta la abundancia de las larvas, la de los adultos de camarón blanco y la presencia de hembras de P. schmitti próximas al momento del desove, no podemos descartar la posibilidad de que se trate de otra especie de Peneido. Debemos pensar en la probabilidad de que la captura con una red de arrastre puede no ser representativa de la fauna de una zona, ni siquiera de su fauna camaronera, que la abundancia de las larvas puede no ser proporcional a la abundancia de los adultos, y además, que cada especie puede tener su época y lugar de desove.

Es necesario tene también en cuenta otro factor. Los adultos de P. schmitti y de P. setiferus son muy cercanos morfológicamente. Sin embargo, las larvas encontradas difieren mucho de las descritas para P. setiferus (Pearson 1939; Heegaard, 1953), lo cual hace pensar que no se trate de una especie como P. schmitti.

Creemos, dados los razonamientos anteriores, que se puede dudar racionalmente de que las larvas descritas en este trabajo correspondan a P. schmitti. Esta incógnita solamente podrá ser resuelta mediante el cultivo de las larvas en condiciones de laboratorio para estar seguros de su identidad y como confirmación, obtener dichas larvas en los lugares y épocas de desove.

Para futuros trabajos el paso inmediato más importante es establecer con seguridad la identidad específica de las larvas encontradas lo cual puede ser logrado mediante el cultivo de las mismas, obtenidas en condiciones de laboratorio de hembras de P. schmitti.

El cultivo de las larvas puede servir además para la descripción de los primeros estadios larvales, es decir, los nauplios y la primera protozoea.

Un estudio completo de las muestras de plancton obtenidas en Tunas de Zaza puede servir para conocer la distribución vertical y horizontal de las larvas de camarones y señalar algún conocimiento sobre las zonas de desove y de cría de la especies comerciales.

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DIEZ VIAJES DE EXPLORACION CON EL BARCO CAMARON I EN LA PLATAFORMA SUDORIENTAL DE CUBA

por

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Extracto

Durante los años 1964-65-66 se realizaron diez viajes de exploración con el barco *Camarón I*, con objeto de encontrar nuevas áreas camaroneras en la plataforma sudoriental de Cuba, aptas para la explotación comercial.

En las áreas encontradas se tomaron datos meteorológicos, oceanográficos, muestras de plancton y ecogramas. Se registraron las capturas, se determinó el rendimiento red/hora para camarones y captura adicional para distintas áreas y horas del día y la distribución de los camarones por tallas, según la especie y el sexo en distintas áreas, así como la presencia de varios organismos capturados junto con los camarones.

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TEN SURVEYS MADE BY CAMARON I OVER THE SOUTHEASTERN PORTION OF THE CONTINENTAL SHELF OFF CUBA

Abstract

Between 1964 and 1966 the Camarón I made ten survey trips to find fresh shrimping grounds suitable for working on a commercial scale on the southeastern portion of the continental shelf off Cuba.

Meteorological and oceanographical data were recorded, and plankton samples and echograms taken. Records were kept of hourly catches per net of both shrimp and other fauna for the different grounds, as related to time of day, shrimp size distribution, by species and sex in the different fishing grounds. Contains lists of other fauna caught along with the shrimp.

DIX CAMPAGNES D'EXPLORATION DU CAMARON I SUR LE PLATEAU CONTINENTAL SUD-EST DE CUBA

Résumé

Entre 1964 et 1966, dix campagnes exploratrices ont été faites par le Camarón I en vue de rechercher sur le plateau continental sud-est de Cuba de nouvelles zones à crevettes susceptibles d'être exploitées commercialement.

Dans les régions étudiées, on a relevé des données météorologiques et océanographiques, prélevé des échantillons de plancton et effectué des échogrammes. On a procédé à des captures, déterminé le rendement horaire des filets en crevettes et autres prises dans certaines zones à diverses heures de la journée, ainsi que la distribution des crevettes par taille, espèce et sexe dans différentes zones, et de divers organismes capturés en même temps que les crevettes.

1 INTRODUCCION

Debido a la importancia de los recursos camaroneros en Cuba, que constituye el tercer puesto en la actividad pesquera de plataforma, se vienen realizando en el Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca de la República de Cuba, distintas investigaciones dirigidas todas ellas a su explotación racional.

El objetivo principal de estas investigaciones consistía en la exploración de nuevas áreas, en las cuales las características y condiciones naturales de las mismas permitirán, además de encontrar las especies comerciales y determinar su abundancia, una explotación comercial con el consiguiente aumento en la producción.

Las exploraciones fueron llevadas a cabo a bordo del barco Camarón I, propiedad del Centro de Investigaciones Pesqueras. El trabajo fue realizado en distintas áreas de la zona comprendida entre el puerto de Casilda y el puerto de Niquero, en la costa sudoriental de Cuba.

Agradecemos la colaboración prestada por el patrón del barco, Mario Martín, así como de la tripulación, en el desarrollo de las investigaciones y, especialmente, al auxiliar de investigación, Fermín Rodríguez Cobos.

2 MATERIALES Y METODOS DE TRABAJO

El barco Camarón I es del tipo balandro, construido en el año 1930 (eslora 13,50 m manga 4,95 m, puntal 1,90 m), de 28,82 toneladas y cámara frigorífica de 4-5 toneladas. Fue reconstruido entre los años 1963 y 1964, para trabajar con una red de arrastre.

Se utilizaron los siguientes tipos de redes: americana semi-balón, mexicana plana y japonesa, con las siguientes medidas de las mallas, tomadas de nudo a nudo: alas: 25mm ; boca: 25 mm ; vientre y cielo: 25 mm ; copo: 20 mm. En la circunferencia del copo, el número de las mallas oscilaba entre 375 y 400 (durante el quinto viaje se utilizó una red con 460 mallas). Las velocidades de los arrastres oscilaban entre 2 y 3 millas por hora.

El material de estudio lo componían alrededor de 13.300 camarones, separados por muestreo de las capturas, con 22.357 kg de camarones y 38.664 kg de captura adicional.

Las capturas se registraron separadamente durante el día y la noche:

06.00 - 18.00 h (día) y 18.00 - 06.00 (noche) verano

07.00 - 19.00 h (día) y 19.00 - 07.00 h (noche) invierno

En algunas ocasiones los arrastres empezaron al anochecer o terminaron al amanecer. Tales arrastres se consideran como nocturnos.

Un área (estación) se consideró de 3 millas náuticas cuadradas, en la cual, según el plan, se debían tomar dos muestras representativas (una diurna y otra nocturna). Cada muestra era de 100 camarones y una sección de captura adicional, tomadas al azar.

Se estableció el peso total de la captura de cada arrastre (aparte de los camarones y de la captura adicional). En cada muestra representativa se determinaron las especies capturadas (de camarones y adicional), de acuerdo con los caracteres morfológicos externos. Para los camarones se determinó el sexo según los caracteres sexuales secundarios y estadios de maduración. Se observó el exoesqueleto para saber si estaba o no en ecdysis.

Con un nonio de corredera (pie de rey) se tomaron de cada camarón las siguientes medidas en milímetros: largo del cephalotórax (Lc2) a partir de la base de la escotadura post-orbital hasta el punto medio-dorsal del borde posterior del cephalotórax; largo total (Lt2) con el cuerpo extendido en un plano horizontal, desde la base de la escotadura post-orbital hasta el borde posterior del último somite abdominal, en su punto medio-dorsal.

Se registró el peso total de la muestra de camarones y su peso por clases (intervalo 5 mm) de los camarones enteros de acuerdo con el largo total (Lt2), expresando las medidas en gramos.

En cada estación se tomó una muestra de plancton (vertical, horizontal u oblicuo) de 10 minutos de duración, utilizando la red cuantitativa de plancton, de la fábrica Rigosha, modelo 2520.

Se tomaron algunos datos meteorológicos, oceanográficos y ecológicos. Las muestras de agua se tomaron con botellas Nansen. La salinidad se determinó por el método Mohr-Knudsen. La penetrabilidad de los sedimentos se determinó mediante un penetrómetro, tipo japonés, de la fábrica Rigosha, modelo 2024.

Se utilizó durante los tres últimos viajes una ecosonda Furuno, con línea blanca, modelo F-603.

Aunque las muestras fueron tomadas en distintas áreas de la extensa plataforma, al sur de las tres provincias (Las Villas, Camagüey y Oriente), de donde provienen la mayoría de las capturas nacionales, las conclusiones no se pueden generalizar y tampoco considerar definitivas, ya que las investigaciones prosiguen.

3 LOS VIAJES DE EXPLORACION

Se efectuaron 10 viajes exploratorios durante los siguientes períodos:

1er	viaje	(14-22 julio 1964)
2do	"	(1-4, 10-21 agosto 1964)
3er	"	(8-16, 21-31 septiembre 1964)
4to	"	(1-22 octubre 1964)
5to	"	(10-12, 16-17 noviembre 1964)
6to	"	(5-8, 12-17 diciembre 1964)
7mo	"	(9-12, 26-29 diciembre 1964; 4-6, 15-19 enero 1965; 1-12 febrero 1965)
8vo	"	(9-24 agosto; 3-6 septiembre 1965)
9no	"	(22-30 noviembre; 1-12 diciembre 1965)
10mo	"	(28 mayo-19 junio 1966)

En el curso de estos viajes se visitaron 49 cuadrículas, o sea, 441 millas naúticas cuadradas; 32 cuadrículas, o sea, 288 millas náuticas cuadradas en las áreas no explotadas y 17 cuadrículas, o sea, 143 millas náuticas cuadradas en las áreas en explotación (véase Fig. 1).

El mayor número de cuadrículas visitadas fue durante el 7mo viaje. Se tomaron en total 112 muestras en áreas no explotadas y 22 muestras en áreas en explotación. El mayor número de muestras se tomó durante el 8vo viaje (42 en áreas no explotadas); el promedio por viaje es de 6,2 cuadrículas visitadas y 13,4 muestras tomadas (2,2 muestras por cada cuadrícula).

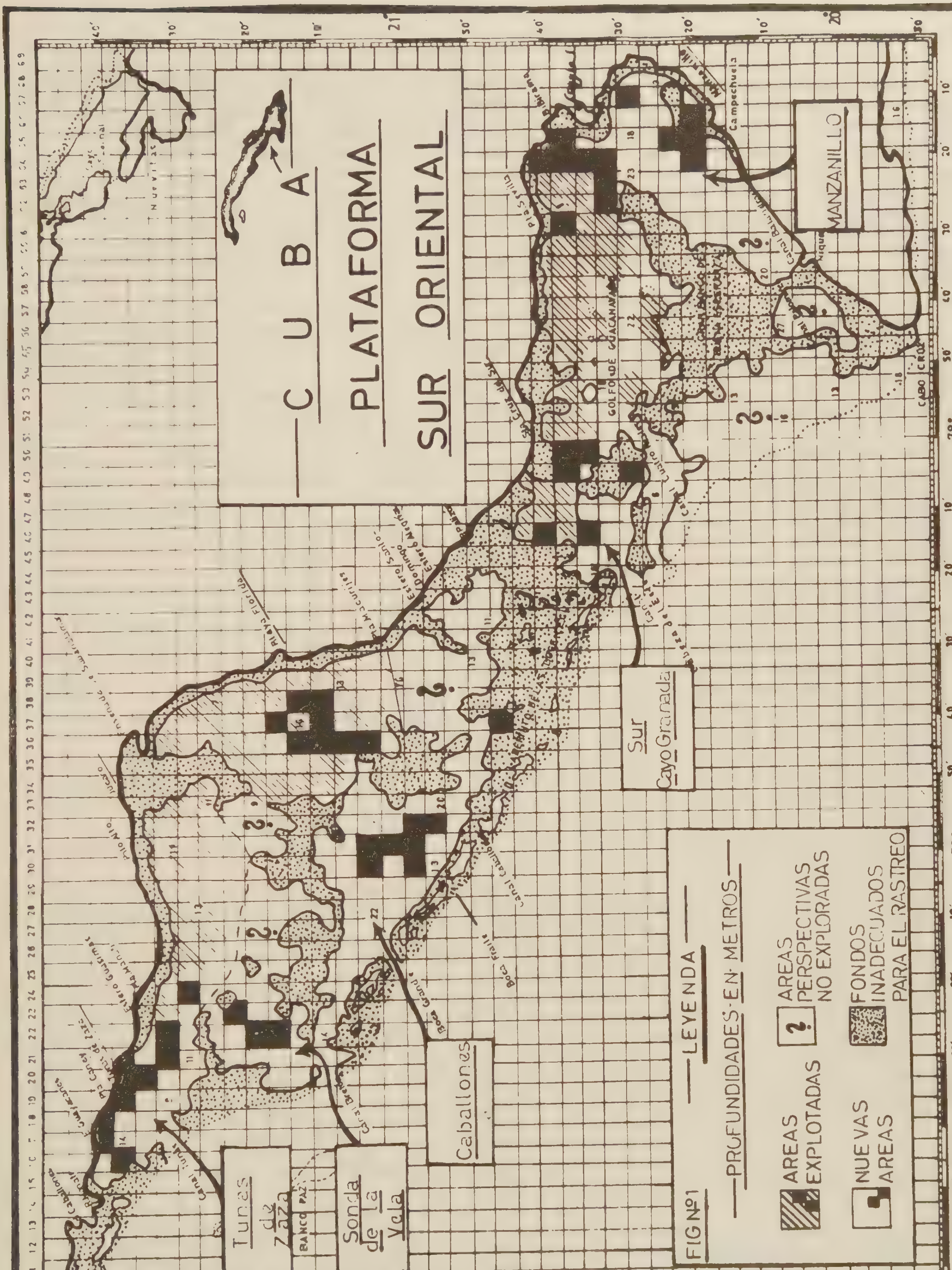

Fig. 1 Mapa tentativo de los "fondos camaroneros" de la plataforma sudoriental.

Los datos hidrobiológicos obtenidos durante los viajes antes mencionados han sido archivados en el Centro de Datos Pesqueros del Departamento de Pesca de la FAO en Roma, y los autores esperan incluirlos en una edición aparte, la cual sería publicada por el Centro de Investigaciones Pesqueras del Instituto Nacional de Pesca de Cuba.

Los nombres, posición geográfica, características del fondo y profundidades de las cuadrículas exploradas se dan en el Cuadro I.

CUADRO I

No.	NOMBRE DEL AREA	Cuadrícula	POSICION GEOGRAFICA	CARACTERISTICAS DEL FONDO	Prof. en metros
1	W Cayo Cucaracha	B-II-37	70°40'-43'W 20°45'-48'N	Fango gris arenoso	12-18
2	NE Cayo Granada	D-II-46	78°12'-15'W 20°39'-42'N	Fango gris con conchas	14-20
3	S Río Jobabo	D-II-64	77°18'-21'W 20°39'-42'N	Fango gris	1- 7
4	W Cayo Infierno	E-II-49	78° 3'- 6'W 20°36'-39'N	Fango gris azulado con conchas	7-16
5	1½ Nm NE Cayo Infierno	E-II-50	78° 0'- 3'W 20°36'-39'N	"	9-15
6	1½ Nm SW Cayo Sevilla	E-II-61	77°27'-30'W 20°36'-39'N	Fango gris	3-11
7	1 Nm W Cayo Tamayo 3 Nm Pta. Birama	E-II-64	77°18'-21'W 30°36'-39'N	"	1-14
8	SE Río Jobabo	E-II-65	77°15'-18'W 20°36'-39'N	"	2- 5
9	SE Cayo Granada	F-II-46	78°12'-15'W 20°33'-36'N	Fango gris con conchas	18-22
10	W Cayo Infierno	F-II-50	78° 0'- 3'W 20°33'-36'N	Fango azulado con conchas	7-17
11	3 Nm E Banco Chinchorro	F-II-64	77°18'-21'W 20°33'-36'N	Fango gris	9-16
12	SE Boya Sta. Clara	G-II-62	77°24'-27'W 20°30'-33'N	"	14-21
13	S Banco Chinchorro	G-II-63	77°21'-24'W 20°30'-33'N	"	14-23
14	SE Banco Chinchorro	G-II-64	77°18'-21'W 20°30'-33'N	"	9-31

Cont.

15	N Cayo Carapacho	H-II-49	78°31'- 6'W 20°27'-30'N	Fango azulado con coral y conchas	9-21
16	4 Nm Pta. Jutía	H-II-67	77°10'-13'W 20°27'-30'N	Fango gris	8-19
17	W Cayo Perla	J-II-65	77°15'-18'W 20°21'-24'N	"	14-20
18	Ensenada de Cuayacanes	J-I-17	79°39'-42'W 29°39'-42'N	"	7- 8
19	Ensenada de Guayacanes	J-I-18	79°36'-39'W 21°39'-42'N	"	7- 9
20	Ensenada de Guayacanes	J-I-19	79°33'-36'W 21°39'-42'N	"	7- 9
21	SE Cayos,Machos de Tierra	K-I-16	79°42'-45'W 21°36'-39'N	Fango gris oscuro	1-20
22	SW Pta. Caney	K-I-18	79°36'-39'W 21°36'-39'N	Fango gris	1-14
23	Ensenada de Guayacanes	K-I-19	79°33'-36'W 21°36'-39'N	"	1-11
24	W Cayo Gua	K-II-64	77°18'-21'W 20°18'-21'N	"	15-20
25	W Cayo Perla	K-II-65	77°15'-18'W 20°18'-21'N	"	5-20
26	W Cayo Gua	K-II-66	77°15'-18'W 20°18'-21'N	"	10-20
27	SW Ensenada Guayacanes	L-I-20	79°30'-33'W 21°33'-36'N	"	1-11
28	SW Pta. Tolete	M-I-21	79°27'-30'W 21°30'-33'N	Fango gris claro	8-18
29	S Pta. Tolete	M-I-22	79°24'-27'W 21°30'-33'N	Fango gris arenoso	8-15
30	SW Pta. Manatí	N-I-24	79°18'-21'W 21°27'-30'N	Fango arenoso gris	10-16
31	3 Nm NE Medano Manatí	P-I-23	79°21'-24'W 21°21'-24'N	Rocoso	
32	2 Nm N Faro Lobo	R-I-22	79°24'-27'W 21°15'-18'W	Fango gris claro	
33	3 Nm N Faro Lobo	R-I-Q-I-22	79°24'-27'W 21°15'-21'N	Fango gris claro arenoso	

Cont.

34 NE Cabezo de la Cana	R-I-37	78°40'-43'W 21°18'-21'N	Fango gris claro	13
35 N Cabezo de Orejón	S-I-36	78°43'-46'W 21°12'-15'N	Fango gris	18-20
36 NW Cayo Sta. María	S-I-37	78°40'-43'W 21°12'-15'N	Fango gris claro	15
37 NE Cayo Sta. María	S-I-38	78°36'-39'W 21°12'-15'N	"	14
38 NW Cabezo de Orejón	T-I-36	78°42'-45'W 21° 9'-12'N	"	20-21
39 1 Nm W Cayo Sta. María 1 Nm SW " " "	T-I-37	78°39'-42'W 21° 9'-12'N	Fango gris oscuro	15
40 SW Cayo Sta. María	T-I-38	78°36'-39'W 21° 9'-12'N	Fango gris claro arenoso	15
41 N Algodón Grande	U-I-36	78°42'-45'W 21° 6'- 9'N	Fango gris claro	20-21
42 3 Nm W Cayo Cuervo	V-I-30	79° 0'- 3'W 21° 3'- 6'N	"	20
43 S Cayo Algodón Grande	V-I-36	78°42'-45'W 21° 3'- 6'N	Fango arenoso gris claro	18
44 S W Cayo Cuervo	V-I-31	78°57'-80°W 21° 3'- 6'N	"	18
45 SW Cayo Cuervo	W-I-31	78°57'-79°W 21° 6'- 9'N	Fango gris claro	18
46 5 Nm W Cayo Cargado	X-I-30	79° 0'- 3'W 20°57'-21°N	Fango gris claro con conchas	18-23
47 3 Nm W Cayo Cargado	X-I-31	78°57'-79°W 20°57'-21°N	Fango gris oscuro	20
48 E de Cayo Cargado	X-I-32	78°54'-57'W 20°57'-21°N	Fango gris claro	18
49 S de Cayo Cargado	Y-I-32	78°54'-57'W 20°54'-57'N	Fango gris claro arenoso	17

4 CONSIDERACIONES ACERCA DE LOS DATOS OBTENIDOS

4.1 Areas

La plataforma sud-oriental situada al sur de las provincias de Las Villas, Camagüey y Oriente, cuenta con unas 5.500 millas náuticas cuadradas, aproximadamente. De toda esta vasta área, están en la actualidad explotadas temporalmente por barcos comerciales, alrededor de 1.300 millas náuticas cuadradas, correspondientes a las siguientes cooperativas: Tunas de Zaza, Júcaro, Playa Florida, Santa Cruz del Sur y Manzanillo.

Esta superficie la componen las siguientes regiones: el área costera entre Tunas de Zaza y Júcaro, parte oriental del Golfo de Ana María hasta Punta Macurijes, área al sur de Santa Cruz del Sur con la de Sevilla-Chinchorro y una parte de la Bahía de Manzanillo, incluyendo la porción correspondiente al río Cauto (Fig. 1).

Las capturas de camarón en estas áreas durante los últimos 6 años (1961-1966), fueron las siguientes:

CUADRO II

AÑO	CAPTURA TOTAL	CAPTURAS CON REDES DE ARRASTRE (x)		CAPTURAS CON OTROS MEDIOS PESQUEROS (x)	
	TON. M.	TON. M.	%	TON. M.	%
1961	1.744	911	52,2	833	47,8
1962	1.462	831	56,9	631	43,1
1963	1.838	885	48,2	953	51,8
1964	3.562	1.424	40,0	2.138	60,0
1965	1.867	850	45,5	1.017	54,5
1966	2.645	1.538	58,1	1.107	41,9
TOTAL:	13.118	6.439	-	6.679	-
PROMEDIO ANUAL:	2.186	1.073	49,0	1.113	51,0

(x) Datos aproximados

El año 1964 fue un año de capturas extraordinarias. El promedio de la captura anual, incluyendo el año 1964, es de 2.186 toneladas y excluyéndolo el promedio (de los 5 años) arroja 1.911 toneladas.

Se determinaron, además, las áreas de explotación respectivas: a) SE de Tunas de Zaza; b) Sonda de la Vela; c) Caballones; d) SW de Santa Cruz del Sur; e) zonas cercanas de Cayo Perla (Manzanillo). Algunas de estas áreas se comenzaron a explotar después de terminadas estas investigaciones.

Además, se determinaron las áreas respectivas, objeto de futuras investigaciones: a) áreas lejanas al sur, entre Tunas de Zaza y Júcaro; b) al suroeste de Punta Macurijes; c) al noroeste de Cayo Perla; d) al oeste y noroeste de Niquero. Durante los viajes se exploró, aproximadamente, 1/11 de la plataforma mencionada.

Los datos sobre los días empleados, arrastres efectuados y capturas obtenidas, se exponen en los Cuadros III y IV. El Cuadro V contiene los promedios de los datos que aparecen en los Cuadros III y IV.

CAUDRO III

AREAS INEXPLOTADAS

Días, horas empleadas y número de arrastres realizados durante los 10 viajes de exploración

VIAJE No.	MES AÑO	DIAS EMPLEADOS	No. ARRASTRES REALIZADOS			HORAS EMPLEADAS		
			Diurnos	Nocturnos	Total	Diurnas	Nocturnas	Total
2	8/64	12	0	30	30	00.00	65.30	65.30
6	12/64	6	4	16	20	9.00	36.05	45.05
7	2/65	5	0	9	9	00.00	14.55	14.55
8	7-8/65	24	11	45	56	27.25	117.10	144.35
9	9-12/65	11	7	19	26	17.30	52.30	70.00
10	5-6/66	23	0	26	26	00.00	63.45	63.45
TOTAL		81	22	145	167	53.55	349.55	403.50

CAUDRO IIIa

AREAS EN EXPLOTACION

VIAJE No.	MES AÑO	DIAS EMPLEADOS	No. ARRASTRES REALIZADOS			HORAS EMPLEADAS		
			Diurnos	Nocturnos	Total	Diurnas	Nocturnas	Total
1	7/64	9	13	21	34	38.35	63.00	101.35
2	8/64	4	8	10	18	25.00	26.30	51.30
3	9/64	19	35	58	93	78.30	140.30	219.00
4	10/64	16	48	37	85	121.35	107.45	229.20
5	11/64	5	6	10	16	8.05	22.30	30.35
6	12/64	4	13	13	26	29.25	33.25	62.50
7	12/64, 1-2/65	22	12	71	83	22.45	193.15	216.00
8	7,8,9/65	13	0	28	28	00.00	71.30	71.30
9	11/65	4	3	9	12	7.45	27.30	35.15
TOTAL		96	138	257	395	331.40	685.55	1017.35

CUADRO IV

Capturas en las distintas áreas durante los 10 viajes de exploración

AREAS INEXPLOTADAS

VIAJE No.	CAPTURAS EN KILOGRAMOS								
	CAMARONES			ADICIONAL			TOTAL		
	DIA	NOCHE	TOTAL	DIA	NOCHE	TOTAL	DIA	NOCHE	TOTAL
2	0	257,6	257,6	0	2918,7	2918,7	0	3176,3	3176,3
6	33,1	308,2	341,3	216,2	1214,4	1430,6	249,3	1522,6	1771,9
7	0	204,7	204,7	0	598,0	598,0	0	802,7	802,7
8	100,7	829,4	930,1	837,2	3726,0	4563,2	937,9	4555,4	5493,3
9	105,8	448,5	554,3	510,6	892,4	1403,0	616,4	1340,9	1957,3
10	0,0	1219,0	1219,0	0	2875,0	2875,0	0	4094,0	4094,0
TOTAL	239,6	3267,4	3507,0	1564,0	12224,5	13788,5	1803,6	15491,9	17295,5

CUADRO IVa

AREAS EN EXPLOTACION

VIAJE No.	CAPTURAS EN KILOGRAMOS								
	CAMARONES			ADICIONAL			TOTAL		
	DIA	NOCHE	TOTAL	DIA	NOCHE	TOTAL	DIA	NOCHE	TOTAL
1	1499,6	1198,3	2697,9	565,8	1322,5	1888,3	2065,4	2520,8	4586,2
2	855,6	1665,2	2520,8	809,6	943,0	1752,6	1665,2	2608,2	4273,4
3	1187,3	2116,0	3303,3	3026,8	5106,0	8132,8	4214,1	7222,0	11436,1
4	3058,5	1821,6	4880,1	2668,0	2392,0	5060,0	5726,5	4213,6	9940,1
5	0,9	107,2	108,1	9,2	308,2	317,4	10,2	415,4	425,6
6	713,0	680,8	1393,8	2024,0	1416,8	3440,8	2737,0	2097,6	4834,6
7	117,3	2065,4	2182,7	828,0	4259,0	5087,0	945,3	6325,0	7270,3
8	0	733,7	733,7	0	1764,1	1764,1	0	2497,8	2497,8
9	119,6	450,8	570,4	230,0	828,0	1058,0	349,6	1278,8	1628,4
TOTAL	7551,8	10839,0	18390,8	10161,4	18,339,6	28501,0	17713,3	29179,2	46892,5

CUADRO V

Promedio de los datos que aparecen en los Cuadros III y IV

AREAS	DIAS POR VIAJE	No.ARRASTRE DIARIOS			HORAS EMPLEA. DIARIAS			CAPTURAS EN KG. POR HORA								
								CAMARONES			ADICIONAL			TOTAL		
		D	N	T	D	N	T	D	N	T	D	N	T	D	N	T
Inexplotadas	13,5	0,3	1,8	2,1	0,7	4,3	5,0	4,4	9,3	8,7	29,0	34,9	34,1	33,4	44,3	42,8
En explotación	10,7	1,4	2,7	4,1	3,5	7,1	10,6	22,7	15,8	18,1	30,5	26,7	28,0	53,2	42,5	46,1
AMBAS	12,1	0,8	2,2	3,1	2,1	5,9	7,8	13,5	12,5	13,4	29,7	30,8	31,5	43,3	43,4	44,4

4.2 Las capturas

Muchos factores influyen en la efectividad de la red y por supuesto en el buen éxito de cada arrastre. Los más importantes son: características del fondo; estado del mar (vientos, corrientes); fases lunares (las capturas disminuyen durante la luna llena) y horas del día y temporada del año.

Entre las 23.00 y 03.00 horas se realizaron en las áreas explotadas las mejores capturas. Entre las 19.00 y 23.00 horas, así como entre las 03.00 y 07.00 horas el volumen de las capturas disminuyó. Las capturas de camarón realizadas durante el día en estas áreas, fueron 40% mayores que durante la noche. Las que empezaban al anochecer o terminaban al amanecer eran algo menores que las de los arrastres efectuados totalmente durante la noche y algo mayores que las capturas de los arrastres efectuados durante el día.

Sin embargo, en las áreas inexplotadas las capturas alcanzaron aproximadamente el 50% de las obtenidas en las explotadas. Por otra parte, las capturas nocturnas del camarón fueron más del 100% mayores que las obtenidas durante el día (Fig. 2).

Las mejores capturas se han obtenido durante los meses invernales (diciembre, enero, febrero); sin embargo, a veces se presentaron buenas capturas durante los meses de julio y agosto.

Las mejores capturas las proporcionaron los arrastres entre 2h30min y 3 horas de duración. Utilizando las redes en parejas, las capturas se redoblan.

Los cálculos aproximados sobre las capturas y las existencias en los fondos camaroneros explorados, según el método de área barrida, facilitan las siguientes consideraciones: suponiendo que la distancia entre las partes anteriores de las alas de una red de arrastre, con puertas, es de 15 metros, y si la velocidad del arrastre es de 2 m.p.h., la red arrastra durante una hora 1/60 millas náuticas cuadradas (55.520 m^2). Durante este tiempo el barco debe capturar, según los datos obtenidos durante estas investigaciones, los siguientes promedios por hora: en las áreas inexplotadas, aproximadamente 9 kg.; en las explotadas, aproximadamente 18 kg. Son necesarias 60 horas para arrastrar una milla náutica cuadrada y, por supuesto, las cantidades de camarones disponibles en esta superficie deberían ser 540 y 1.080 kg , respectivamente.

Se considera que un determinado porcentaje de los camarones disponibles no son capturados, "introduciéndose" éstos profundamente en el fondo fangoso y escapando por ambos lados de las alas, el cielo y el vientre de la red. En el caso de escapar:

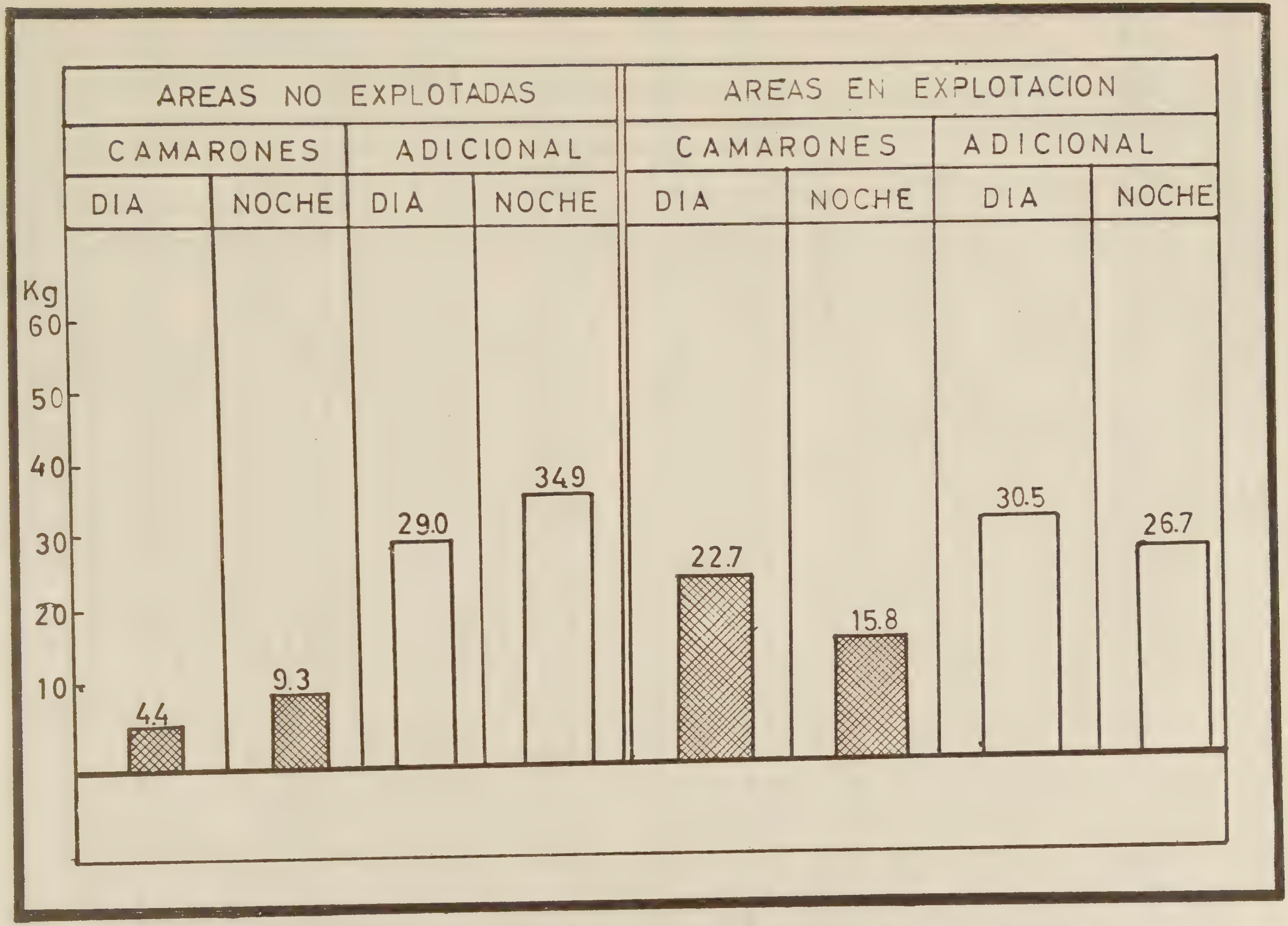

Fig. 2 Promedio de capturas kg/h durante diez viajes del barco Camarón I

E/29

El 50% de las existencias oscilaría entre 810 y 1.620 kg
" 60% " " " " " 864 y 1.728 "
" 70% " " " " " 918 y 1.836 "
" 80% " " " " " 972 y 1.944 "
" 90% " " " " " 1.026 y 2.052 "

El 90% de escape se puede considerar como muy alto y aplicable únicamente durante los arrastres iniciales en las áreas inexplotadas. Rastreando en una misma área (R-I-22 = Sonda de la Vela), se capturó como sigue:

12 V 1966. . . . . 5,5 kg /hora
13 V " . . . . 5,5 " "
14 V " . . . . 6,4 " "
28 V " . . . . .23,0 " "
29 V " . . . . .27,6 " "
30 V " . . . . .23,9 " "
4 VI " . . . . .17,5 " "
5 VI " . . . . .23,0 " "
14 VI " . . . . .16,1 " "

El promedio anual durante 5 años (1961-1966, excluyendo 1964 con las capturas extraordinarias), es de 1.003 toneladas capturadas con un promedio de 35 barcos, o sea, 28,7 toneladas por barco.

Si cada uno de estos barcos (promedio de captura por hora 13,5 kg) trabajando diariamente 12 horas, arrastra mensualmente (22 días) 264 horas y anualmente (8 meses) aproximadamente 2.112 horas, su captura anual arroja 28,5 toneladas.

Siguiendo los cálculos anteriores y tomando como captura media de "morralla" (captura adicional), aproximadamente 30 kg por hora, debería capturar anualmente cada barco 63 toneladas y 35 barcos 2.205 toneladas.

Las capturas obtenidas estaban compuestas principalmente por dos especies comerciales: camarón acaramelado (acanalado) (Penaeus duorarum Burkenroad) y camarón blanco (no acanalado) (Penaeus schmitti Burkenroad). No obstante hay áreas como el Golfo de Ana María, Sonda de la Vela y Caballones, en las que solamente se capturó camarón acaramelado.

En algunas ocasiones se capturaron escasos individuos de las siguientes especies: camarón acaramelado (Penaeus brasiliensis, Latreille); camarón acaramelado (Penaeus aztecus, Ives); camarón fijador (Trachypenaeus similis, Smith); y camarón reyecito (Sicyonia typica, Boeck).

Aunque en la mayoría de las áreas de actual explotación habitan ambas especies, la mayor parte de las capturas la compone el camarón acaramelado. En el muestreo realizado el 65% de los ejemplares pertenecía a la especie P. duorarum y el 35% a la especie P. schmitti. El camarón acaramelado se capturó en mayores cantidades, debido a las siguientes razones: la especie tiene su distribución geográfica más amplia, y los arrastres se efectuaron mayormente durante la noche, cuando esta especie está más disponible a los medios de captura.

El camarón blanco se ha encontrado en menor porcentaje, debido a que su habitat está limitado a las áreas cercanas a la desembocadura de los ríos y aguas marinas adyacentes, donde no se realizan los arrastres debido a la poca profundidad.

La mayoría de las clases modales de una y otra especies capturadas, son de tamaños mayores que la clase que representa el tamaño mínimo comercial.

Durante el 7° y 8° viaje en el Golfo de Ana María y el área de Caballones, respectivamente, se realizaron diferentes estudios para determinar la relación entre el longitud (Lt2) y el peso (Pt) de los ejemplares capturados. Basándose en los 4.990 camarones estudiados, se confeccionó la relación largo-peso presentada en la Fig. 3.

Se utilizó la siguiente ecuación, calculada en base a los estudios efectuados con 4.598 camarones del área de Manzanillo:

$$P = 0.000007.\ L^{3.229}$$

Los valores observados en el Golfo de Ana María y Caballones, se ajustan con pequeñas variaciones a la regresión rectilineal que aparece en la Fig. 4.

Se observó que los ejemplares colocados en los estanques con una capa gruesa (15 cm) de fango en el fondo, se enterraban en él, dejando fuera solamente los ojos (véase Fuss, 1964). Sin embargo, en su habitat natural parece que no sucede lo mismo, ya que cuando se realiza el primer arrastre las capturas son pobres, pero en el siguiente la captura aumenta considerablemente. Analizando lo expuesto, se hace la siguiente pregunta ¿dónde se encuentra el camarón al realizarse el primer arrastre? Al comprobar que en el segundo las capturas son mucho mayores, se puede desechar la idea de que se desplazan de un lugar a otro velozmente. Queda por aceptar la probabilidad de que estén enterrados profundamente en los sedimentos fango-arenosos, para que la red no los capture durante el primer arrastre y salen apenas ésta remueve los sedimentos sobre su habitat.

4.3 Relaciones ecológicas

Los fondos de las áreas exploradas se hallan mayormente entre 8 y 20 m de profundidad y alcanzan en algunas ocasiones, debido a los bajos y a las fosas, entre 3 y 29 m. La mayoría de estos fondos son blandos y están constituidos por sedimentos de fango gris claro. Hay menos fondos fango-arenosos de color gris oscuro o azulado con valvas de moluscos y restos de corales y solamente hay algunos rocosos, impropios para el rastreo. La penetrabilidad de los fondos blandos es entre 20 y 71 cm (71 cm = cuadrícula G-II-63).

4.4 Captura adicional

Junto con los camarones se capturaron muchos otros organismos, llamados por los pescadores con el nombre común de "morralla" (captura adicional).

La relación del volumen (peso) en los arrastres entre los camarones y la captura adicional, varía mucho según las áreas. Esta es grande en las inexplotadas y pequeña en las explotadas, en comparación con las capturas de camarón. Sin embargo, no difiere mucho entre el día y la noche.

A continuación se ofrece un cuadro comparativo de las capturas en distintas áreas y horas del día (como índice se tomó la captura por hora de camarones durante el día, en áreas no explotadas):

AREA	CAMARON		CAPTURA ADICIONAL	
	Día	Noche	Día	Noche
Inexplotada	1,0	2,1	6,6	7,9
Explotada	5,1	3,6	6,9	6,1

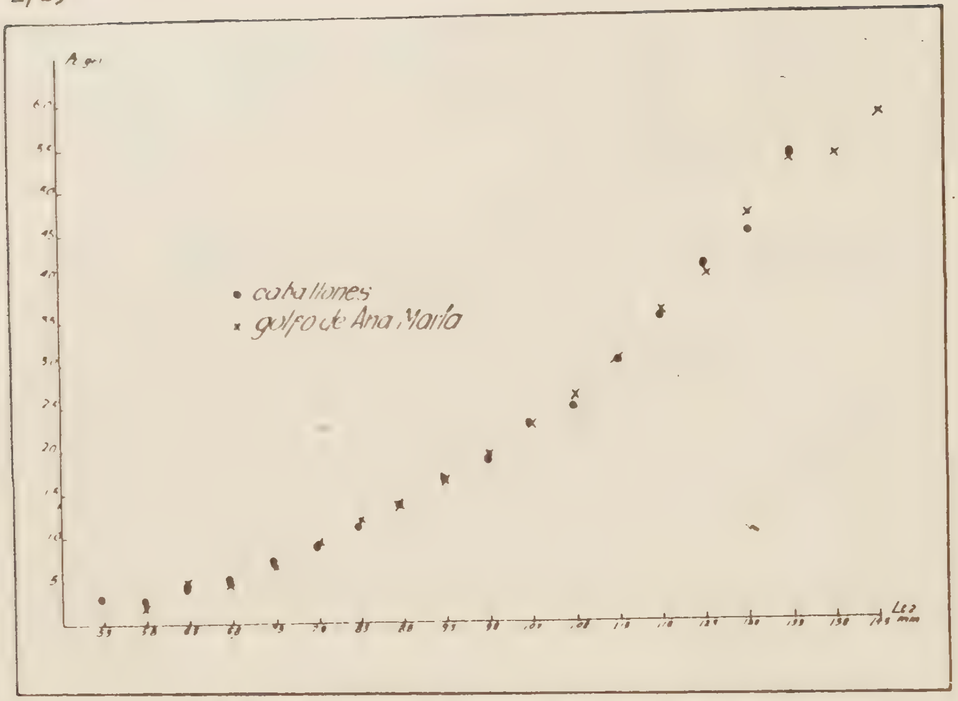

Fig. 3 Relación largo-peso, Caballones y Golfo de Ana María 1965.

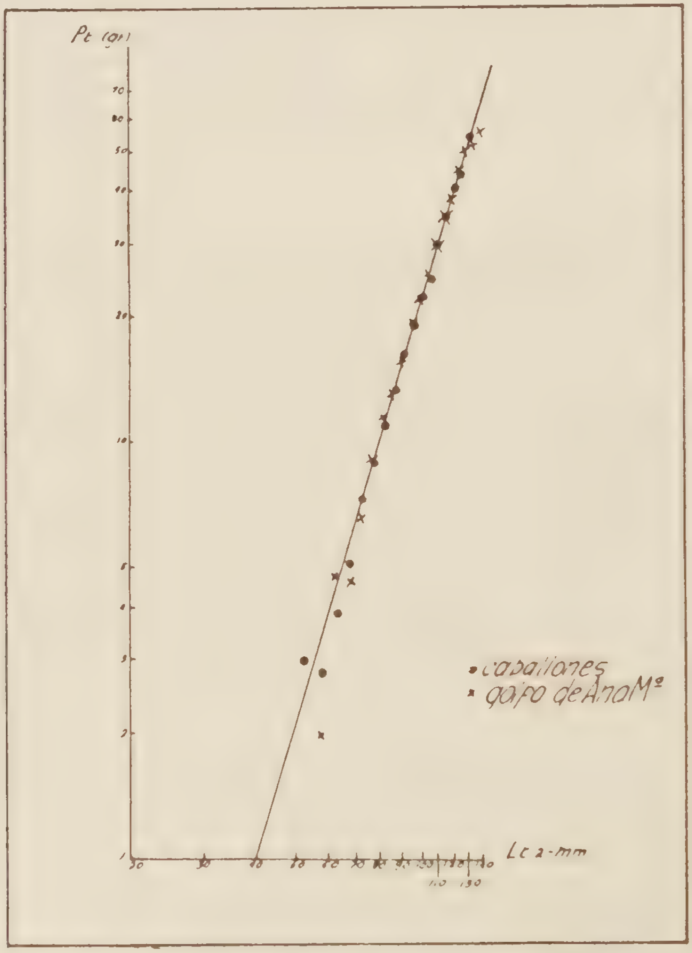

Fig. 4 Relacion largo-peso, $P - 0.000007.L^{3.229}$.

5 REFERENCIAS

Fuss Jr., C.M., 1964 Shrimp behavior as related to gear research and development; 1. Burrowing behavior and responses to mechanical stimulus. In Modern fishing gear of the world. London, Fishing News (Books) Ltd., vol.2: 563-6.

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